BONUS POSTER: THE RUSSIANS WE LOVE ON THE AIRSHOW CIRCUIT

AIR&SPACE

Smithsonian

MAY 2002

MAD FOR MiGs

AND OTHER FORMER FOES FLYING AIRSHOWS

Will the new corps of air marshals make flying safer?

PAGE 42

photo courtesy of NASA

SUBJECT Mission officials relax after the successful launch of Apollo 11.

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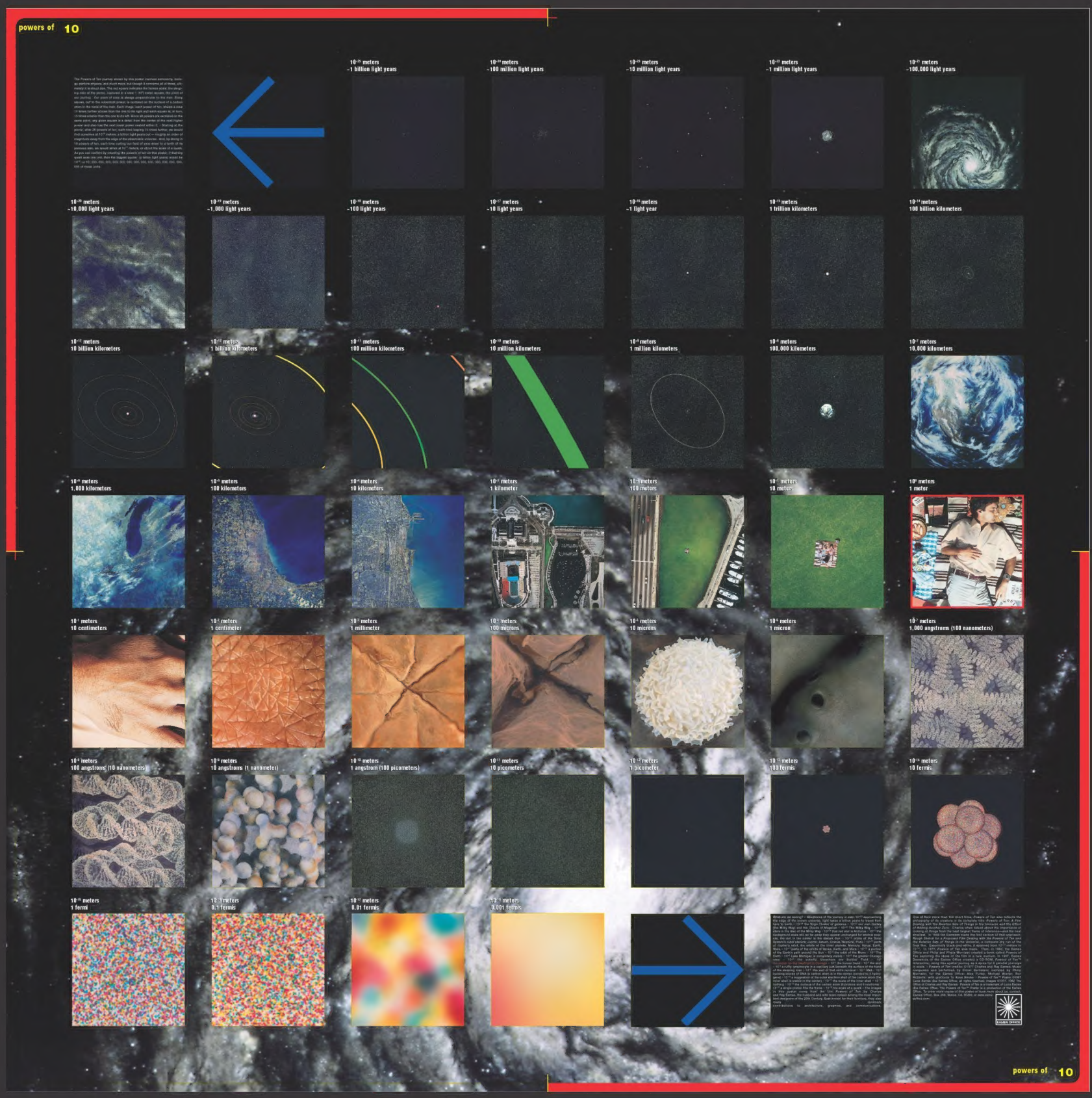

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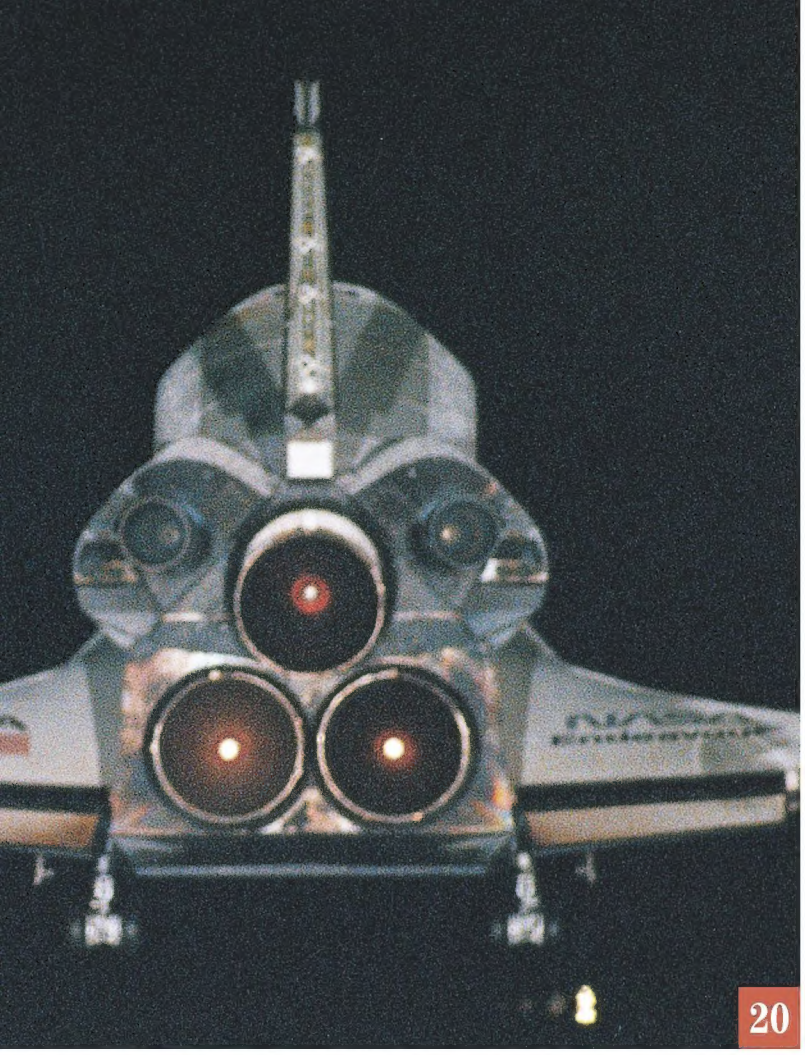

AIR&SPACE

Smithsonian

April/May 2002
Volume 17 • Number 1

FEATURES

Cover:
Is it the snow on the Canadian peak below that makes Paul Entrekin's MiG-15 seem to hang in the air or the artistry of photographer Katsuhiko Tokunaga?

DEPARTMENTS

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A Look Back at Lindbergh

Seventy-five years ago, a quiet young airmail pilot from the Midwest made history when, on May 21, 1927, he landed his sturdy Ryan monoplane, the *Spirit of St. Louis*, at Paris' Le Bourget airfield. Expecting little fanfare, Charles A. Lindbergh carried several letters of introduction. Upon landing, he was overwhelmed by 150,000 well-wishers, and from that moment on, his life was dominated by this one event.

A year earlier, this son of a Minnesota congressman had been the chief pilot for Robertson Aircraft Corporation, a predecessor of American Airlines. When he learned of the $25,000 prize offered by New York hotel owner and French expatriot Raymond Ortieg for the first nonstop flight between New York and Paris, Lindbergh became inspired. Airplane manufacturers rebuffed him until Ryan Airlines, a small company in San Diego, California, agreed to build him an aircraft. In two months Donald Hall and his Ryan team, with significant input from Lindbergh, designed and built the Ryan NYP. The aircraft was christened *Spirit of St. Louis* in honor of Lindbergh's friends and associates in Missouri who financed the flight.

Lindbergh planned carefully, and after a 33-and-a-half-hour flight that spanned 3,610 miles, he arrived in Paris. His resulting fame enabled him to promote air travel and science, and his work developing routes for TWA and Pan American Airways was instrumental to the success of both airlines. Through the Guggenheims, a family that promoted aviation, Lindbergh helped rocket pioneer Robert Goddard. With Alexis Carrel, Lindbergh also helped to develop a practical perfusion pump, an early form of an artificial heart.

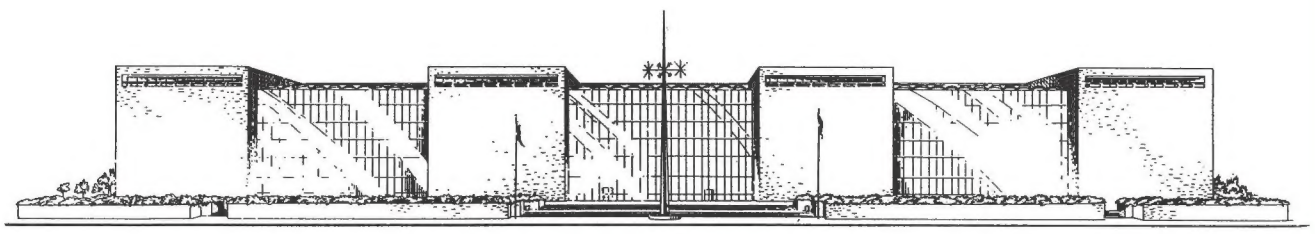
The Smithsonian Institution is part of the Lindbergh story: The morning after his arrival in Paris, the flier awoke to find a telegram from Smithsonian Secretary Charles G. Abbott requesting the *Spirit of St. Louis* for the national collection; curator Paul E. Garber composed the message. Lindbergh and his backers eagerly agreed, and, following the completion of successful U.S. and Latin American tours, he sold the *Spirit* to the Smithsonian—for $1. On April 30, 1928, the aircraft arrived in Washington, and it has remained in our care ever since.

This year the Museum will celebrate Lindbergh's flight and the 100th anniversary of his birth. On May 23 Reeve Lindbergh will give the annual Charles A. Lindbergh Memorial Lecture. The youngest child of Charles and Anne Morrow Lindbergh, Reeve is a good friend of the Museum, and she will present a reminiscence of her father.

Reeve Lindbergh has also written a foreword to a new book: This month, in cooperation with Harry N. Abrams, Inc., we are publishing *Charles Lindbergh and the* Spirit of St. Louis. Written by Dominick A. Pisano, chairman of the aeronautics department, and F. Robert van der Linden, the curator for the *Spirit*. Intended for a popular audience, this beautiful book is richly illustrated with original color photography and rare archival images.

It is our hope that in this anniversary year, these events will help the public attain a better understanding of this complicated and accomplished man and his equally famous aircraft.

—J.R. Dailey is the director of the National Air and Space Museum.



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LETTERS

A Microjet With Mega-Problems

What is so remarkable about Debbie Gary's story ("Back in the Saddle," Above & Beyond, Feb./Mar. 2002) is not that she has managed to survive performing at airshows off and on for 30 years but that she survived flying the Bud Light Microjet. As an experienced airshow pilot who has flown that BD-5J myself, I can attest to its squirrelly characteristics, only one of which is the attention required to maintain fuel balance between the wings. A low-level flameout during an aerobatic routine is an airshow jet pilot's worst nightmare, but to have survived *two* of them, as Debbie has, is tempting fate!

Paul Entrekin
Pensacola, Florida

Two Shelves Short of a Library

I have been a big fan of the National Air and Space Museum and your magazine since both began. It's a wonder that I am, though, given the sorry amount of attention both have given to my particular field of aeronautical interest.

I learned how low lighter-than-air buffs are rated when, a few years after the Museum opened, it closed its Balloon and Airship gallery. *Air & Space* has ignored the topic as well, except for the occasional piece on a blimp. Now the latest insult: your list of "must have" books ("Building a Great Air and Space Library," Feb./Mar. 2002). Surprise, surprise! Not a book on lighter-than-air craft or airships among them.

Here are some classics that your article overlooked:

1. *My Airships* by Alberto Santos-Dumont
2. *Graf Zeppelin* by J. Gordon Vaeth. The story of the airship of the same name and its fascinating skipper, Hugo Eckener
3. *The Zeppelin in Combat* by Douglas H. Robinson. The definitive history of the German Naval Airship Division in World War I, written by the dean of airship historians
4. *Giants In The Sky* by Douglas H. Robinson. Probably the best one-volume history of rigid airships
5. *Up Ship!* by Douglas H. Robinson and Charles H. Keller. The story of the rigid airship in the U.S. Navy
6. *Sky Ships* by William F. Althoff. The history of the entire U.S. Navy lighter-than-air program
7. *The Airships* Akron *and* Macon by Richard K. Smith. An illustrated history of the two largest aircraft ever built in the United States
8. *The Eagle Aloft* by NASM curator Tom Crouch.

Dennis R. Kromm
Aurora, Illinois

I was exceedingly disappointed that you did not include one book on helicopters. May I suggest the following:

1. *Chickenhawk* by Robert Mason
2. *The Illustrated Encyclopedia of Helicopters* by Michael J. Taylor
3. *The Bell Helicopter Textron Story* by David A. Brown

Have you received any complaints about the lack of books on gliders, ultralights, etc.?

David Delisio
Walkersville, Maryland

Editors' reply: We will now.

That's One Homesick Bat

During World War II, my father worked for Bell Labs as a design engineer assigned to the Bat project, specifically the Bat's S-band radar homing device ("The Bat," Restoration, Dec. 2001/Jan. 2002). One of his stories was particularly memorable. In the early stages of testing the radar homing apparatus, the team experienced difficulties with its radar signal emission. My father never mentioned how many times this happened, but upon being detached from the PB4Y-2 Privateer, the missile immediately did a half-circle, attempting to make its way back to the airplane.

My father was never one for emoting, yet the few times he spoke of this, it was quite obvious that the odd behavior of the Bat produced some very anxious moments aboard that old Privateer.

Joseph A. Burkart Jr.
Gouldsboro, Maine

Missing the Thrust

In "Ready, Set, Flap!" (Dec. 2001/Jan. 2002) James DeLaurier says his is the only wing to provide both lift and thrust. Doesn't a helicopter's propeller blade provide both lift and thrust?

Joe Kishel
Bay Pines, Florida

Editors' reply: A helicopter achieves thrust indirectly by tilting the lift vector in a given direction. That isn't the same as thrust. The new tiltrotor does provide lift and thrust, but not at the same time.

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Simmer Down, Hun

Perhaps Robert Hanson's Hun was vicious because it was wound too tight ("Air Combat U," Dec. 2001/Jan. 2002). My T.O. 1F-100D-1 states that maximum high-pressure rotor rpm (revolutions per minute) was approximately 9,980, not the 38,000 he states.

Allan Shukle
Deland, Florida

Pig Tales

My brother flew FB-111s for several years and loved them ("The Plane With No Name," Feb./Mar. 2002). Not only were they the fastest aircraft in the world below 500 feet, but if you ejected you took a quarter of the airplane with you; there was no uncomfortable parachute or seat pan survival kit to sit on. (For those of us in the helicopter community, an F-111 seat cushion is one of the most sought-after comfort items.)

As for the U.S. nickname, as I recall the -111 was called the Aardvark because of its early safety record: It was an ugly, ground burrowing animal.

William S. McCann
Grass Valley, California

Hats off to the Royal Australian Air Force for keeping the Switchblade Edsels aloft and improving the breed. You should know, however, that Queensland is an Australian state, not a province.

Colonel Robert J Powers
U.S. Air Force (ret.)
Shreveport, Louisiana

More Stowaway Airplanes

Both the Seiran ("All and Nothing," Oct./Nov. 2001) and the Benson airplane, carried on the French submarine Surcouf ("A French Seiran," Letters, Feb./Mar. 2002), were preceded by three other submarine-carried aircraft: the U.S. Martin MS2 floatplane, the Italian navy's Macchi M-53 floatplane, and the Germans' Caspar U-1.

Donald M. Layton
Salinas, California

Fifty-Cent Thrills

"The Fifty-Cent Classic" (Oldies & Oddities, Feb./Mar. 2002) reminded me of when my buddy Merritt Fiske and I were World War I airplane enthusiasts and made rubber-band-powered balsa models of the Fokker D.VII, the Sopwith Camel, and other airplanes from the big war, which had ended only 10 to 12 years earlier. Our biggest thrill was launching a Fokker triplane from the second story window, touching a match to it, and watching "the Baron" go down in flames.

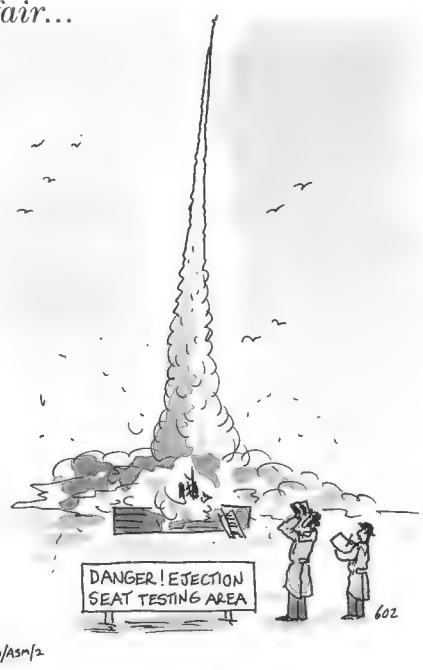
I am sure some of these models were Guillow's, and we owe him thanks for a great idea that contributed to a happy childhood.

Harold Sigwell
Summerfield, Florida

Stupid Boyfriend Tricks

How about one more "stupid" story ("Stupid Airplane Tricks," Oct./Nov. 2001)? In the spring of 1945, I was given the opportunity to fly and evaluate a brand-new and unmarked P-47N out of the Army Air Forces Gunnery School in Suffolk County, New York. At the time my flame worked for the Shell Oil Company, in the RCA Building in Rockefeller Center. I decided to fly past her office—on the 37th floor. My flyby must have convinced her that I'd do anything for her, because we were married the following July. And this year, we will celebrate our 57th anniversary.

In the early days, development of ejection seats was a hit-or-miss affair...



"Make a note to reduce the charges."

Philip L. Munn Jr.
Glastonbury, Connecticut

Plug in, Take off

In "Fly Green" (Soundings, Feb./Mar. 2002), Jim Dunn states that his is the first electrically-powered piloted airplane. I suggest he visit the Web site of Astro Flight and read about the exploits of Bob Boucher. Bob and his brother have been instrumental in developing electric aircraft, manned and radio-controlled, both solar and battery powered. Bob worked with Paul MacCready of *Gossamer Condor* fame to produce the *Gossamer Penguin*, which on May 16, 1980, made the first piloted flight in a solar/electric powered aircraft. Bob later was part of the development team behind the first piloted aircraft to cross the English Channel powered by solar/electric energy.

Chris Zettel
Fort Myers, Florida

Don't Try This at Home

In the early 1940s my best friend's father, a mechanic at the local Ford dealer, purchased two Allison engines from a scrap dealer ("Masters of the V-12," Feb./Mar. 2002). The engines had come from a P-38 that had crashed. He decided to make one working engine from the two wrecked ones. The engine was in the garage for months. One weekend he dragged the engine out on the driveway, and with the help of a friend, a can full of gas, and a wobble pump, they fired the monster up.

In about five minutes the police arrived, having received calls from all over the neighborhood about some awful noise nearby. I don't remember what happened to the engine or the mountain of leftover parts, but the incident did create a lasting memory for me.

David Dewitt
Riverside, California

Correction

Feb./Mar. 2002, Sightings: The picture of India shows a location at 75° 49' East, not West.

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"What can a retired pilot do?"

PHOTO: MARK AVINO

"After devoting my life to aviation, I couldn't *just* retire. I remain connected to a field I love through our support of the Museum. Our gift annuities will help inspire future pilots."

— CAPTAIN AND MRS. ELLIOTT

During a visit to the National Air and Space Museum, Captain and Mrs. Elliott stop in front of the DC-3 in the Air Transportation Gallery.

Captain George William Elliott's romance with aviation spanned more than four wonderful decades. He began his career as a flight instructor in the cockpit of a Curtiss P-40. He trained to fly the Northrop P-61C Black Widow, and he retired as a United Airlines captain.

"I had to find a way to stay involved," says Captain Elliott. He and his wife, Virginia, discovered they could arrange a charitable gift annuity to benefit the National Air and Space Museum. "Our gift brought us such joy," adds Virginia Elliott. "George wanted to share his passion for aviation with others." They were so delighted that a year later the Elliotts completed a second annuity.

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Lindbergh vs. Atlantic: the Sequel

CHAD SLATTERY

Erik Lindbergh gazes at the funky sculpture of the *Spirit of St. Louis* he created from a chunk of salvaged, old-growth cedar. When rheumatoid arthritis had prevented him from becoming a flight instructor several years before—in fact had nearly crippled him—he turned his energies to making rustic furniture and sculptures from unusual pieces of wood. He had initially resisted his client's request to sculpt the stout Ryan NYP monoplane, but as it came into shape, he noticed how the natural waves in the wood rode along the wing structure. "I started to think about the ocean in those waves," he recalls. And he thought about something else.

For the last few months he had been taking a new arthritis drug and was moving better than he had in years. In that moment, his aspiration to fly solo across the Atlantic—like his grandfather, Charles A. Lindbergh, did for the first time 75 years ago—seemed possible.

On April 14, Lindbergh will follow his grandfather's route, beginning in San Diego, stopping in St. Louis, and then flying on to New York. From there, he will head nonstop to Paris, cruising at 185 mph, much faster than the original *Spirit*'s 108 mph. That should put him at Le Bourget Airport in about 19 hours, a little more than half the time of the original flight.

"Transponder set, doors latched, time noted—looks like 3:10—start engine."

On this February day at Gillespie Field in San Diego, California, Lindbergh, now 37, is here on a brief stop to announce his plan to the local media. He's also busy logging more flight time in a Lancair Columbia 300, the single-engine, low-wing, composite-materials *New Spirit of St. Louis* he'll fly to Paris. He chose this aircraft, he says, "because it has a side stick control and room inside the cockpit so I can stretch—very important when you have arthritis—making that flight easier on my body." Now, after a thorough preflight inspection, he's invited me to join him on a short ride.

The *New Spirit* has been customized with fuel tanks in the wings, like the original, but it also features the latest navigation and communications systems, including Global Positioning System hardware, satellite telephone, e-mail, and a Web cam. "He—and we—will know where he is at all times, a big difference from the dead reckoning navigation his grandfather used," says flight director Gregg E. Maryniak, executive director of the X PRIZE Foundation, which is producing this adventure.

Lindbergh, who has logged just under 1,000 flight hours, has spent months training for the flight and is being advised by Stanley R. Mohler, director of aerospace medicine at Wright State University in Dayton, Ohio. From daily physical exercise that includes bicycle riding and playing Hacky Sack, to taking a sea survival training course, to warming up with a seven-hour flight over the Gulf of Mexico, he is covering all bases. "Like Grandfather, I am trying to eliminate every possible risk factor," he says. "When

WEB FINDS

www.fiddlersgreen.net

Former Sikorsky engineer Chip Fyn has started a company that takes a high-tech approach to a traditionally low-tech pastime. Fiddler's Green sells an eclectic series of paper model kits on its Web site. Each week the site pumps out thousands of samples of old favorites, like the Piper J-3 Cub and the Gee Bee R-1 racer, that can be downloaded free. Fiddler's Green delivers a PDF file; you supply a couple of pieces of file card cover stock and a four-color inkjet printer. The models can be assembled in an evening, requiring only scissors and glue. As soon as the glue is dry, the model is ready for display (or zipping around at arm's length if you're up to making appropriate engine noises).

The kits reflect a well-planned combination of the fewest number of parts and the simplest construction techniques to produce a three-dimensional replica. Each aircraft has its own Web page, with a mix of history, nostalgia, eye candy, and sound effects. Other models, ranging from SPADs to Spitfires and SkyCranes to space shuttles, sell for a couple of dollars each. Says Fyn, "They're pretty good, considering what they are."

—Cam Martin

I take off from New York, I will be as ready as humanly possible—and I will have slept the night before, unlike Grandfather."

As a Lindbergh, Erik is aviation royalty. While that has certainly "opened some doors," he says, it has also brought moments of personal struggle for identity. "I had to come to terms with the fact that I will never be able to fill his shoes—they're unfillable," he says. "Having had my physical self die to a certain degree and then having another chance liberated me from the expectations and comparisons. I have to be true to myself in this."

He chose to make the flights not just to celebrate the 75th anniversary but to raise awareness about the Lindbergh Foundation, which furthers his grandparents' philosophy of keeping a balance between technology and the environment; the Arthritis Foundation; and the X PRIZE Foundation, whose $10,000,000 prize for the first private reusable spacecraft to carry passengers to an altitude of 62 miles and back, Lindbergh says, "will help open the door to space travel" in much the same way that the Orteig Prize, which his grandfather won, opened up aviation.

"This flight is all about hope," he says as we walk back to the hangar. "If I can reach kids and inspire people to have hope, to persevere and overcome obstacles in their life, then it will be a success for me."

To follow the flight in real time, visit the Web site *www.Xprize.org*.

—A.J.S. Rayl

Big Booster, Small Satellite, Long Journey

Last November, nearly 40 years after NASA dispatched Mariner 2 to Venus, the first robotic probe to successfully survey another planet, the agency funded a spacecraft to blast off for a decade-long journey to Pluto, finally completing the reconnaissance of the entire solar system.

"It's been a very, very long haul," says Carolyn Porco, a Southwest Research Institute scientist and head of the imaging team for a project called New Horizons, which was selected to build and launch a spacecraft to survey Pluto, its moon Charon, and objects in the Kuiper Belt, which is beyond the orbit of Pluto and Neptune.

The team, which also includes Johns Hopkins University's Applied Physics Laboratory, Stanford University, Ball Aerospace, and NASA's Goddard Spaceflight Center in Maryland, defeated a rival proposal offered by NASA's planetary exploration experts at the Jet Propulsion Laboratory in Pasadena, California, and Lockheed Martin Astronautics.

Although the space budget for fiscal year 2003 contains no funding for the Pluto probe, last year Congress directed NASA to fund the mission. Efforts to gain support for a mission to Pluto already have taken far longer than the 10 years that will pass between the probe's launch in January 2006 and its sprint past Pluto in 2016.

There's no chance for the spacecraft to settle into orbit around the distant planet for an in-depth study. The satellite will be moving so fast and Pluto's gravity field is so small that the amount of propellant needed to slow it down would make the mission cost-prohibitive.

Just to get to Pluto in a relatively timely fashion, the team plans to buy the biggest unmanned booster available—either an Atlas 5 or a Delta 4, both of which are scheduled to debut this year—to hurl the satellite toward Jupiter in a record-breaking 14 months. In comparison, the Jupiter-orbiting Galileo spacecraft and the Saturn-bound Cassini orbiter took five years to cover the same distance.

JOHNS HOPKINS UNIVERSITY (APL/SWRI)

Once the Pluto probe passes Jupiter, it will be put into hibernation, rousing itself about once a year to adjust its flight path, says Southwest Research Institute's Alan Stern, head of the New Horizon science team. Keeping the spacecraft shut down will trim payroll for ground control teams and help keep the mission to its $430 million budget.

Though Pluto carries the designation of a planet, it is a Kuiper Belt object, whose growth, like that of its lesser-known siblings, was arrested billions of years ago. It remains a frozen sample of the primordial solar system.

"This is a fascinating region of space," said Andrew Cheng, APL project scientist. "It's full of small, icy, dirty and rocky objects that started to build into planets

HEADS UP

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Salute to Veterans 2002

Memorial Day Weekend Airshow
May 25–26, 10 a.m.–4 p.m.
Columbia Regional Airport
Highway 63 South
Columbia, MO 65201
Phone (573) 443-2651
www.salute.org

The 14th annual tribute to the nation's military veterans and active-duty personnel will feature static displays and flights by the Kansas City Dawn Patrol Nieuport 11s, P-51s, SNJ Texans, and a P-47, T-28, C-47, AH-1 Cobra, UH-1 Huey, C-130, A-10, F-15, and F/A-18. (As more aircraft sign up for the show, they will be listed on the Salute to Veterans Web site.) A Missing Man formation will be flown by a B-17, B-25s, and an SB2C Curtiss Helldiver. On Monday, Memorial Day, the Salute to Veterans parade, kicked off by the U.S. Army Golden Knights parachute team, will be overflown by the airshow performers. No admission charge, free parking. Wear your best red, white, and blue.

but, for some mysterious reason, stopped in mid-stride."

After the Pluto encounter, the spacecraft will fly into the Kuiper Belt region for a series of encounters with objects that have yet to be selected. "This mission is all delayed gratification," says Stern. "Once we get there, it'll be non-stop science."

The probe will be outfitted with four-color, high-resolution miniature cameras, infrared and ultraviolet spectrometers, radio science instruments, and space plasma experiments. It will be programmed to carry out its studies, as one-way communications with Earth will take about five hours from Pluto and even longer from the Kuiper Belt region.

Stern, who participated in his first space mission in his 20s, says that now that he's in his 40s, he's beginning to look forward to his senior years. "I've started to really look at 60-year-olds in a whole new light," he says.

—Irene Brown

COURTESY DR. ROBERT PLEMING

PLAN B

"Pago Pago Tower, Atlantis Is Turning Final for Runway 23"

If things ever went badly during a shuttle launch—and they'd have to go very badly indeed—the astronauts could find themselves ten minutes later sitting on a runway at the Myrtle Beach International Airport in South Carolina. Or (a few more minutes later) at the Atlantic City International Airport in New Jersey. Or maybe the Francis S. Gabreski Airport on Long Island, where, if not exactly plying the final frontier, they'd at least be safe on the ground, with a harrowing story to tell.

NASA is nothing if not thorough, and each time the shuttle launches, mission controllers have worked out in advance dozens of detailed abort scenarios covering every kind of failure. The worst-case abort in the event of one of the vehicle's three main engines going out is the RTLS, or return to launch site, in which the orbiter drops its fuel tank and swoops around to land back at Kennedy Space Center in Florida. If it loses a single engine further along in its trajectory, the shuttle can still limp across the Atlantic to a transoceanic abort landing (TAL) in Spain or Africa. But if two or three engines go out early during the ascent, the best hope is ECAL—east coast abort landing. In this case the orbiter would be directed to land at the nearest military or commercial airport with a long enough runway (7,500 feet or better) and the air navigation equipment to help guide the shuttle down.

For due-east launches, that means Bermuda. But for the more northerly route required to reach the International Space Station, NASA has negotiated agreements with several airports along the east coast of the United States that meet the specs. The first "stop" would be the Wilmington International Airport in North Carolina. From there, moving north during a window lasting all of about 10 minutes, the shuttle could land either in Cherry Point, North Carolina; Oceana Naval Air Station or NASA's Wallops Flight Facility in Virginia; Atlantic City; Gabreski; the Otis Air National Guard Base on Cape Cod; the Pease Tradeport in New Hampshire; or one of several airports in Canada.

Rescue teams at the military airfields receive NASA-sponsored training on shuttle evacuation procedures and hazardous materials on board. The civilian airports are asked simply to cordon off an area around the shuttle until NASA help arrives. Each of the ECAL sites gets a call from NASA before launch to make sure everything's still operational.

The list of contingency landing strips doesn't stop with ECAL sites, however. A couple dozen more airfields, from Le Tube, France, to Lincoln, Nebraska, could be used in even more unlikely emergency situations, such as the shuttle overshooting its primary transoceanic abort landing site or running into serious trouble during the return to Earth. And NASA hopes to negotiate agreements with 17 more emergency sites, including airports on Easter Island and Pago Pago.

—Tony Reichhardt

Vulcanologists Wanted

She's stripped in the hangar—
awaiting our repair
Now, so vulnerable and in our care.
This awesome lady longing to fly
Still waiting for funding to be up on high.

So begins the verse offered by the Vulcan Operating Company Ltd. of Bruntingthorpe Airfield, Lutterworth, Leicestershire, England. The VOC pleads poetically for British pounds, U.S. dollars, or your choice of currency, including sweat, to get a Vulcan bomber on the international airshow circuit.

Of 134 forged at the Woodford, Cheshire plant of A.V. Roe (Avro) Ltd., 19 Vulcans remain worldwide, with 16 on static display. Only three Vulcans can taxi under their own power, and the only one restorable to flight is that owned by the VOC: Royal Air Force Vulcan XH558, the last of the Vulcans to fly.

In 1948, Roy Chadwick, designer of the Lancaster heavy bomber, set out to make a high-speed bomber with a delta blended-wing-body planform. In 1952, a prototype appeared, initially with no defensive armament but with a pioneering suite of electronic countermeasures. In cold-war Britain, the Vulcan was the head of the V-Bomber family, which included the Vickers-Armstrong Valiant and Handley Page Victor. By the end of the 1970s, Vulcans had served in maritime reconnaissance and even as inflight refuelers.

Four Rolls-Royce Bristol-Siddeley Olympus 202 twin-spool turbojets provide the Vulcan with a total thrust of 68,000 pounds. (The Vulcan powerplant and blended-wing design were subsequently chosen for the Concorde.) "It's not exactly a quiet aircraft," says VOC director Robert Pleming. "A single Vulcan has a sound like a fleet of military jets, or all of the Blue Angels."

The Vulcan got its first and only battle experience in the Falkland Islands. The "Black Buck" raids of 1982 set a record for long-range bombing missions. Three years later, the Vulcan fleet slipped from active service. Vulcan XH558 was purchased in 1993 from the Ministry of Defence by C. Walton Ltd., owner of the Vulcan Operating Company.

XH558 is a creampuff. Delivered on June 30, 1960, it had logged less than 600 hours when it last touched down March 23, 1993. Pleming vows to return it to airworthiness by March 2003.

Backed by members of Parliament, letters of support, and names on petitions, the VOC has raised and spent $600,000 to date but can't proceed with the final phase until it banks another $1.5 million. The money will fund 10 months of work, including 35,000 man-hours of technician and fitter time, and 10,000 more in design engineering.

Pleming hopes to have the bomber ready in 2004 to tour the U.S. airshow circuit. Organizers plan 40 performances per airshow season. In addition to the $2.2 million restoration, operations may run $1.6 million per year for the Vulcan's new lifetime—another six years, tops.

With the support of more than a hundred companies, the VOC stocks 16,000 line item spares, including seven zero-time Olympus engines, but it needs more of everything—materials, tools, components, and direct assistance from former RAF or industry suppliers. Depending on their generosity, supporters qualify for anything from a lapel pin to a season's exclusive sponsorship of the tour. "At the risk of being cheeky, can I also mention where to make donations?" asks Pleming. "Vulcan to the Sky Foundation, Westport, Connecticut."

—Roger A. Mola

Time Flies

For as long as there have been pilots, there have been pilots' watches. Big, manly watches. Watches with huge numbers that glow in the dark. Watches with lots of small, intricate dials that you can't possibly read, plus an outer rotating bezel that can either calculate your fuel burn or act as a circular slide rule. Ancient dusty watches that have crossed continents and oceans, encircled the world, and reached the moon.

Tourneau TimeMachine on 57th and Madison in New York City, which bills itself as the world's largest watch store, wanted to pay homage to aviation watches. In its downstairs museum, it built a big display of wing sections and hung photos of everything from the Wright brothers to the Concorde; it also put eight watches in a display case. All of them came from the International Watch Company of Schaffhausen, Switzerland. They were at first placed inside the leading edge of a wing covered with plastic and locked, but "it wasn't safe enough," says Andrew Turin, Tourneau store director.

The collection's prize is an oversize 52 Calibre pilot's watch, circa 1940. It has a huge black face and iridescent numbers like a stopwatch, plus an aging, extra-long brown strap. "The pilot could wear it over his coat or on his leg," Turin explains. Temperature fluctuations wouldn't bother the 52 Calibre, nor would pressure changes resulting from takeoff and landing. Its main feature, however, is its soft-iron inner case, which is resistant to magnetic fields. "Watches and magnetism don't work well together," Turin says. "It causes them to run fast." That magnetism comes from all the iron in the airplane's engine. The watch is a bit of a rarity. Though some 1,200 were built, "it's the only one I've ever seen," Turin adds.

The other seven watches are smaller, with black leather bands and black faces—although the most modern has at least three tiny dials on its face. They can be pricey little timepieces. One, a 1957 Mark IX from the Royal Air Force, recently sold for $12,000 at an Internet auction.

—Phil Scott

COLLECTIONS

Museum of Mountain Flying
Missoula International Airport
Missoula, MT 59808
(406) 549-8488
10 a.m.–5 p.m. every day,
Memorial Day–Oct. 1;
10 a.m.–5 p.m. Thurs.–Mon.
the rest of the year

COURTESY MUSEUM OF MOUNTAIN FLYING

A Ford Tri-motor clears the pine trees after a mail drop at a remote mountain ranch, belching blue exhaust as it claws for altitude in the thin air. Parachutes blossom behind a DC-3 on a hot August afternoon as smokejumpers drop into a raging forest fire while a TBM tanker dumps red fire retardant nearby. And regional airline passengers breathe a sigh of relief at a safe landing during a sudden spring snowstorm in the northern Rockies.

The Museum of Mountain Flying recalls the challenges of these and other western U.S. aviation adventures as it traces the history of civil aviation in some of the country's toughest flying environments. Museum founders started the collection to preserve the history of Missoula's legendary Johnson Flying Service, which pioneered mountain flying and served as the first smokejumping contractor (the Army took lessons from the program in developing its own paratrooper corps). Since opening in 1993, the museum has expanded to include all areas of aviation, working with the Experimental Aircraft Association to sponsor airshows and hosting aviation art exhibits, World War II aircraft displays, and seminars.

The collection includes a C-45 Twin Beech, a 1941 Stearman, three homebuilts, a 1947 Federal flatbed airport truck, a World War II Jeep, a large model aircraft collection, and displays of smokejumper memorabilia, parachutes, and historic photos.

The museum recently acquired the Douglas C-47 that dropped smokejumpers on Montana's notorious 1949 Mann Gulch fire, which hours later killed 12 of the jumpers and a wilderness guard and inspired the Norman Maclean book *Young Men and Fire*. The transport will be restored to its smokejumping configuration and will take center stage this summer, when the museum moves into a larger hangar, now under construction.

—Paul M. Ross Jr.

CAROLYN RUSSO

Curator Frank Winter oversees a collection of science fiction artifacts.

Buck Rogers in the 21st Century

The reality of spaceflight is tangible; a spacecraft or flight spare enables us to preserve the technology involved in a Mars landing so that future generations can understand how it was done. But how do you preserve a "sensation" so that future generations will appreciate its impact on society?

Philip Francis Nowlan may not be one of the biggest names in science fiction, but he is the creator of one of the biggest science fiction cartoon characters—Buck Rogers, a figure synonymous with spaceflight. Rogers has found a permanent home at the National Air and Space Museum; in 1996, the Museum acquired a wide-ranging collection of memorabilia that documents this pop culture icon.

In an article entitled "Armageddon—2419 A.D.," which he wrote for the August 1927 issue of *Amazing Stories*, Nowlan introduced Anthony "Buck" Rogers, an ordinary man whose job is to inspect abandoned coal mines for radioactive gases. On one inspection the mine collapses, and Rogers is trapped in a chamber full of the gases. Eventually he loses consciousness, but the gases keep him alive, and he awakes nearly 500 years later. After adjusting to the shock of his situation, Rogers discovers that the United States has been conquered by Mongolians, who rule the country from floating cities while forcing Americans to hide in the forests below. Unknown to the Mongolians, however, the Americans have become organized, secretly making technological advances. Now, along with Rogers, they are about to launch the Second War of Independence.

The editor of *Amazing Stories*, Hugo Gernsback, prophesied that many of the devices described by Nowlan, such as the jet airplane and the walkie-talkie, would "no doubt come true," and that the tale would become more popular over time. He was right on all predictions. On January 7, 1929, "Buck Rogers in the 25th Century" debuted as the first syndicated science fiction comic strip, and it quickly became a huge hit. By 1932, a Buck Rogers radio program was airing four times a week. Commercial spinoffs, including toy ray guns, games, uniforms, tin spaceships, and trading cards, were sold everywhere. And Buck's success also inspired several cartoon copycats, including Flash Gordon and Captain Midnight. When the Buck Rogers film series debuted in 1939, both young and old stood in lines for hours to buy tickets.

Buck Rogers mania foreshadowed the fan worship of such science fiction favorites as Star Trek and Star Wars, and it no doubt encouraged the dreams of the generation of Americans who would ultimately make spaceflight a reality. All of this creates an interesting problem for the Museum. The reality of spaceflight is tangible; a spacecraft or flight spare enables us to preserve the technology involved in a Mars landing so that future generations can understand how it was done. But how do you preserve a "sensation" so that future generations will appreciate its impact on society? That task has fallen to Frank Winter, a Museum curator of space history.

As a boy in New York, Winter grew up watching "Captain Video and His Video Rangers" (1949–55) on television. Each week Captain Video would climb on board the Galaxy II and rocket to another planet in a never-ending battle against "crime, tyranny, injustice and the unreasoning fury of nature!" Winter

remembers that once the show's actors came to a theater in his neighborhood, where they performed a skit and talked to the kids afterward. To this day, Winter remains a Captain Video fan.

It's an interest that serves him well in his job at the Museum, where he is curator of rocketry and popular culture. He is responsible for thousands of artifacts, ranging from Star Wars trading cards to Apollo Saturn V rockets. Winter had long felt that Buck Rogers and other early space heroes were a part of American spaceflight history worth examining, and he wanted to acquire some memorabilia. Unfortunately, because of their rarity and price, many important objects remained in the hands of private collectors. That situation changed in 1996 when the Museum was approached by Michael O'Harro, a successful restaurateur who had collected more than 2,200 space toys. Would the Museum be interested?

"I was astounded, " recalls Winter, after he had inspected the collection. "It was like walking into Tut's Tomb!" Over the years, O'Harro had collected many rare items, including original comic strips, a Buck Rogers watch, tin spaceships, lead figures, games, trading cards, and a prototype ray gun that was used to create a production toy. Although most centered on Buck Rogers, there were also items based on Flash Gordon and even Captain Video. O'Harro's collection spanned the entire history of space toys, from Buck Rogers in the 1920s to Star Wars in the 1980s. Winter felt that every bit of it belonged in the Museum. Then the work began. Each object in the Museum's collection must be entered into a database that contains information about the physical characteristics of the object and as much historical information as possible. A simple Buck Rogers trading card, for example, requires as much basic paperwork as a flight-qualified Saturn V.

As a result of O'Harro's generosity, the Museum now has an excellent core collection that will give future generations an opportunity to learn about Buck Rogers' appeal. Winter points out, however, that the collection is not complete. "It would be nice to find a Buck Rogers bike and some flying suits," he muses. Then he smiles and says, "A few more Captain Video objects would also be nice."

—Bob Craddock is a planetary geologist at the National Air and Space Museum's Center for Earth and Planetary Studies.

At the Movies

On April 17, the National Air and Space Museum will premiere *Space Station*, a 3-D IMAX film that takes viewers aboard the International Space Station, orbiting some 220 miles above Earth. Twenty-five astronauts and cosmonauts from the United States, Canada, Japan, Russia, and Europe shot more than 12 miles of 65-mm film between December 1998 and July 2001; *Space Station* features 3-D sequences shot during the construction of the ISS, as well as zero-G glides through the station's interior. The film also shows remote shots of the ISS, such as this image, taken by a 3-D IMAX camera mounted in the cargo bay of the space shuttle *Discovery*.

NASA

MUSEUM CALENDAR

April 11 "Hubble to Hubble—Remaking the Universe." Historian Robert Smith will examine the research of astronomer Edwin Hubble. Tickets may be obtained through *www.tickets.com* or by calling (800) 529-2440. Langley IMAX Theater, 8 p.m.

April 13 & May 4 Evening Stargazing. Join astronomer Sean O'Brien for an evening of telescopic observing. Dusk to 11 p.m. at Sky Meadows State Park in Virginia. For directions, call (540) 592-3556.

April 24 "An Evening With Colonel Joseph F. 'Joe' Cotton." Retired test pilot Joe Cotton, who flew more than 16,000 hours in 80 aircraft types, will discuss his lengthy career. Tickets may be obtained at *www.tickets.com* or by calling (800) 529-2440. Langley IMAX Theater, 7:30 p.m.

April 27 Astronomy Fair at the National Air and Space Museum. Learn how to use telescopes. 10 a.m. to 4 p.m., South Lobby.

"Time By the Stars." Learn how to tell time without the aid of clocks. Einstein Planetarium, 6 p.m.

May 1 "Why Does an Astronomer Study Something She Cannot See?" Astronomer Vera Rubin will discuss her research proving the existence of dark matter. Tickets may be obtained through *www.tickets.com* or by calling (800) 529-2440. Langley IMAX Theater, 8 p.m.

May 2 Space Day. Join John Glenn and hundreds of teachers for a day of educational activities at the National Air and Space Museum. 10 a.m. to 3 p.m.

May 23 Charles A. Lindbergh Memorial Lecture. Reeve Lindbergh will reflect on her experiences as daughter of aviator Charles Lindbergh. Tickets may be obtained through *www.tickets.com* or by calling (800) 529-2440. Langley IMAX Theater, 8 p.m.

Except where noted, no tickets or reservations are required. To find out more, visit www.nasm.edu *or call the Smithsonian Information line at (202) 357-2700; TTY (202) 357-1729.*

Mission X


LOCKHEED MARTIN AERONAUTICS (2)

Arthur Tomassetti is go for Mission X in the X-35B.

Edwards Air Force Base, California, July 20, 2001. Mission X was to be the graduation exercise for the Lockheed Martin X-35B, the Short Take-Off and Vertical Landing (STOVL) concept demonstration aircraft.

The STOVL aircraft fulfills only one of three service roles the X-35 Joint Strike Fighter was designed for. The STOVL design will replace the Marines' AV-8B Harrier. There's also a conventional-takeoff-and-landing (CTOL) version for the U.S. Air Force, and a beefier version for the Navy's punishing catapult launches and arrested landings. The call sign of all X-35 test pilots is "Hat Trick," which is the term for three goals scored by one hockey player in a single game.

The sortie was to consist of a short takeoff, climbing to 25,000 feet, making a supersonic dash, and returning to the field for a vertical landing. Each event, in and of itself, was not a breakthrough achievement and had been accomplished on a previous X-35B sortie, but putting them all together on one flight would be an aviation first. Previous STOVL aircraft achieved supersonic speeds when they had been put in a steep dive, but today we would up the ante by making a level supersonic dash.

The day started with a pre-sunrise flight brief. The early start allowed our team to complete testing before other units at Edwards started flight operations. Additionally, today the field was to close from 10 to 11:30 a.m. for a memorial service. We planned to be done with our test by 9, so there was little time to spare.

Until now, I had flown the aircraft for only three brief vertical takeoffs and landings, which gave me a total flight time of about three minutes. The first flight of the day would basically familiarize me with STOVL flight, allowing me to get a feel for the airplane while completing just a few test points. After landing, the ground crew would hot-refuel the jet (load fuel with the engine running), and I would take off again. The second flight would be Mission X.

With all the buildup we had given Mission X over the past three years, I suppose I should have been more excited. Actually, I was more focused on completing all the test events and, more importantly, not making a mistake. Although Mission X consisted of only the three basic events, there were several other test events planned to fill the rest of the sortie. As I was gathering my flight cards (which include tests to perform, the order in which to execute them, pertinent cautions or limitations, and space to make notes), the lead military flight test engineer shook my hand and said, "Good luck, and don't forget to have fun out there." I guess I must have looked more worried than excited. I thanked him and walked to the hangar to get my flight gear. After suiting up and completing my preflight, I gave the airplane my traditional pat on the nose. I wouldn't say I'm superstitious, but that day I wasn't taking any chances.

The first flight went very well, and I was able to get a good feel for the airplane while it was in the STOVL mode. Perhaps the most surprising thing about the flight was that there were no surprises. All that time in the simulator had paid off. In fact, the previous night, the simulator team stuck around late so I could practice the mission profile a few times. Another reason the flight had gone well was that the airplane was very easy to fly. Although the Harrier is a remarkable airplane and an amazing achievement in its own right, it is difficult to fly. It takes a long time to train a Harrier pilot, and he must practice a lot to stay proficient. If the first flight in the X-35B was any indication, we were on the right track to making STOVL flight much easier.

During the few minutes it took to refuel, I went over the sequence of events for the Mission X flight. When the test conductor called on the radio to talk about prioritizing the events in the test cards, I realized that we were going to cut it close to the field closing time. There wasn't any room for mistakes or repeats. The little bit of extra pressure would help keep me on my toes.

I was finally ready to go. Once in position for takeoff I moved the Thrust Vector Lever (TVL) back about an inch, initiating the process of converting the aircraft from CTOL mode to STOVL. Behind the cockpit, four sets of doors were opening. This would allow air to flow through the lift fan and enable the vectoring rear nozzle to move through its full range of travel. While the doors were opening, the clutch was engaging,

transferring power from the engine to the lift fan. The only noticeable change in the cockpit was an increase in noise as the lift fan spooled up.

A "good conversion" call came from the control room, which confirmed the indications in the cockpit. I radioed the chase aircraft that I was ready and slowly advanced the throttle and released the brakes. The aircraft quickly accelerated down the runway, and at 80 knots, after only 200 feet, I vectored the thrust to 60 degrees and the aircraft leapt off the ground. I completed the post-takeoff checks, climbed through 5,000 feet, and converted the aircraft from STOVL mode back to CTOL by moving the TVL fully forward.

Climbing to test altitude, I turned toward the supersonic corridor, the airspace designated for supersonic flight tests. Upon reaching 25,000 feet, I stabilized briefly, then advanced the throttle to full afterburner. As the afterburner engaged and the aircraft rapidly accelerated, I was pressed back in the seat. I watched the head-up display on the windscreen to make sure that I was maintaining level flight, but mostly I focused on the airspeed indicator. As the airspeed passed Mach 1.0, I adjusted the throttle for Mach 1.05, the target speed for the test. In the cockpit, the transition through the sound barrier was barely noticeable.

Now two of three Mission X events were complete—just one more to go. As I started slowing down for the next test point, I checked fuel and time. It was getting close, but there was still enough time to get everything done before the field closed. I set up for the next event, a set of slow-speed flying-qualities tests. These test points consisted of performing pitch, yaw, and roll evaluations at speeds of about 140 knots (160 mph) and below. It took about 10 minutes to complete the set. Checking fuel and time again, I realized that we probably didn't have enough of either to complete the last set of tests. After a quick discussion with the test conductor, we decided to head back to the field to set up for the vertical landing.

I began the descent and turned the airplane back toward the runway. Passing through 5,000 feet I slowed below 200 knots, converted the aircraft back to STOVL mode, and began my final approach. Once over the runway, I started the deceleration to the hover. I gradually moved the TVL aft, increasing the angle of thrust from 0 degrees (thrust straight aft) toward the hover setting (thrust about perpendicular to the ground). I adjusted the rate at which I moved the TVL by visually judging my deceleration rate as I approached the desired hover spot. The process is somewhat analogous to adjusting pressure on a car's brake pedal to stop smoothly at a traffic light. The aircraft responds to control inputs in a hover the same as it does in forward flight. Left stick banks and moves the airplane left. Forward stick pitches the nose low. Increasing and decreasing the throttle controls altitude. I set up to come to a stop just short of the landing pad, which was just off the runway at about midfield. I brought the aircraft to a hover over the runway, stabilized for a few seconds, and began to cross over to a position above the landing pad. Once the aircraft was centered over the landing site, I reduced the throttle slightly to begin the descent. Out of the corner of my eye, I caught a glimpse of the many spectators in the observation area. No one was running away from the airplane—a good sign.

Out of the corner of my eye, I caught a glimpse of the crowd in the observation area. No one was running away from the airplane—a good sign.

The aircraft firmly touched down and I quickly chopped the throttle to idle. "Touchdown," I called over the radio. Mission X was complete.

During the taxi back to the ramp, I completed the after-landing checklist and had a few minutes to let the events of the past hour sink in. As I began the process of shutting down the airplane, I glanced outside at the crowd that was approaching the airplane and finally started to relax. Things had gone well: We had accomplished most of our test points and made it back before the field closed. By completing Mission X, the X-35B had just made aviation history, with me in the driver's seat. I glanced at my watch before getting out of the cockpit: just before 10 a.m. All things considered, not bad for a morning's work.

—Major Arthur Tomassetti
U.S. Marine Corps

You Go, Girl!

DAVID PETERS

In 1995, having worked for over a year at the Marshall Space Flight Center in Huntsville, Alabama, designing the payload training curriculum for the International Space Station, I was ready for a vacation. My wife Linda and I decided to visit our friends Frank and Naomi Stewart and Naomi's daughter, Rachel, in Bozeman, Montana, a grand place to relax. For the first three days, we spent every waking hour on the slopes. On the fourth day, a spring blizzard struck. Frank and I felt we'd best prepare for the storm, which we did mainly by opening the occasional bottle of wine. Frank, also an engineer, perused an article I had written for *Air & Space* that became the book *Rocket Boys* and then the film *October Sky*. He lifted a critical eye. "Can you still build a rocket, Homer?"

"Why, it's like swimming," I said. "Once you build a rocket, you never forget. Building a rocket is about as simple a thing as there is."

The truth was, I hadn't built a rocket for 35 years. But I wasn't going to let that stop me. At that moment I spied a Barbie doll belonging to Rachel. "Frank, old boy," I said, "I can not only still build a rocket. I can make anything into a rocket, including that doll."

"Well, put your money where your mouth is, NASA boy!" Frank roared, slapping down a whole dollar bill.

The next day we slipped and slid to a department store, where I expected to find your standard Barbie. Instead, I was astonished to discover a Skating Star Barbie, Shopping Spree Barbie, Valentine Barbie, Teacher Barbie, Biker Barbie, and Picnic Barbie. After watching Frank and me furtively casing the doll section, a clerk advised us that these were just a few of hundreds of choices. "Is there a Rocket Barbie?" I asked.

The clerk thought for a moment, then said, "Why, dear, I don't believe there is."

"Well, there is now," I told her, and chose the ponytailed Picnic Barbie, mainly because she was the cheapest.

"She has accessories," the clerk said.

"Oh, she won't need any accessories where she's going," I replied.

She gave me a suspicious look. "And where is that?"

I glanced at the ceiling. "Far, far away."

I went after a few other supplies, mainly epoxy glue and a small model-rocket motor from a hobby store.

Barbie's dimensions were perfect for flight. She was tall and slim, a very aerodynamic design. Her long legs were perfect stabilizers. The only problem I saw to her liftoff was the location of the rocket motor. She had to be perfectly balanced or her flight might turn erratic. I made a careful study of her trim, weighing and balancing to determine her center of gravity. Results indicated that the best location for the motor was on her stomach, nestled in her cleavage. But Frank said that would look like Barbie was glued face-first to a stove pipe. I decided to let art rule over sound engineering principles and placed the motor on her back. To stabilize her, I used a couple of Frank's smallest fishing sinkers, artfully glued to her buttocks.

"Won't her legs melt?" Linda asked. She was right. A heat shield was required. Barbie's gingham dress was traded for an aluminum foil pants and blouse. She sure looked snazzy.

Frank and I scooped out a launch pad on the driveway. Old Joe, Frank's bird dog, was designated our range recovery crew. To my surprise, an audience quickly gathered. Before we got down to business, everybody wanted to take a look at Rocket Barbie. "The Incredible Hulk might fly even better," said Al Cunningham, an engineering professor. "He's broad of back. Might take on an engine better than your slim Barbie here."

"Nothing can fly like a Barbie," I retorted, with the assurance of the truly ignorant.

I positioned Rocket Barbie on her launch rod. Frank ran the ignition wires back a few feet.

I pushed the launch button and the rocket on Barbie's back spewed a shower of sparks. As if waving goodbye, she spun around the rod once, and then, her hands pointing skyward, Barbie hurtled upward with a grand *whoosh!* The crowd gasped. Old Joe began to bark. Up she went, until she disappeared into the night sky.

"Oh, look!" Rachel cried. "Barbie flew right out of her shoes!" There on the driveway sat Barbie's tiny shoes. Somewhere high above, a barefoot Rocket Barbie flew. Then I heard her rocket give out a last gasp. Barbie had turned ballistic and was on her way down. "Go get her, Joe!" Frank cried, and our recovery crew bounded off.

A few minutes later, Old Joe reappeared out of the snow, Barbie clamped in his jaws. Her aluminum pants were a little scorched and her hair was in disarray, but otherwise she was unharmed. I took Frank's dollar, then gave it back to him, since he'd helped build Rocket Barbie. I held her aloft for all to admire. Old men took off their hats, women sobbed into their scarves, and little boys and girls ran in excitement. At least, that's the way I remember it.

—Homer Hickam

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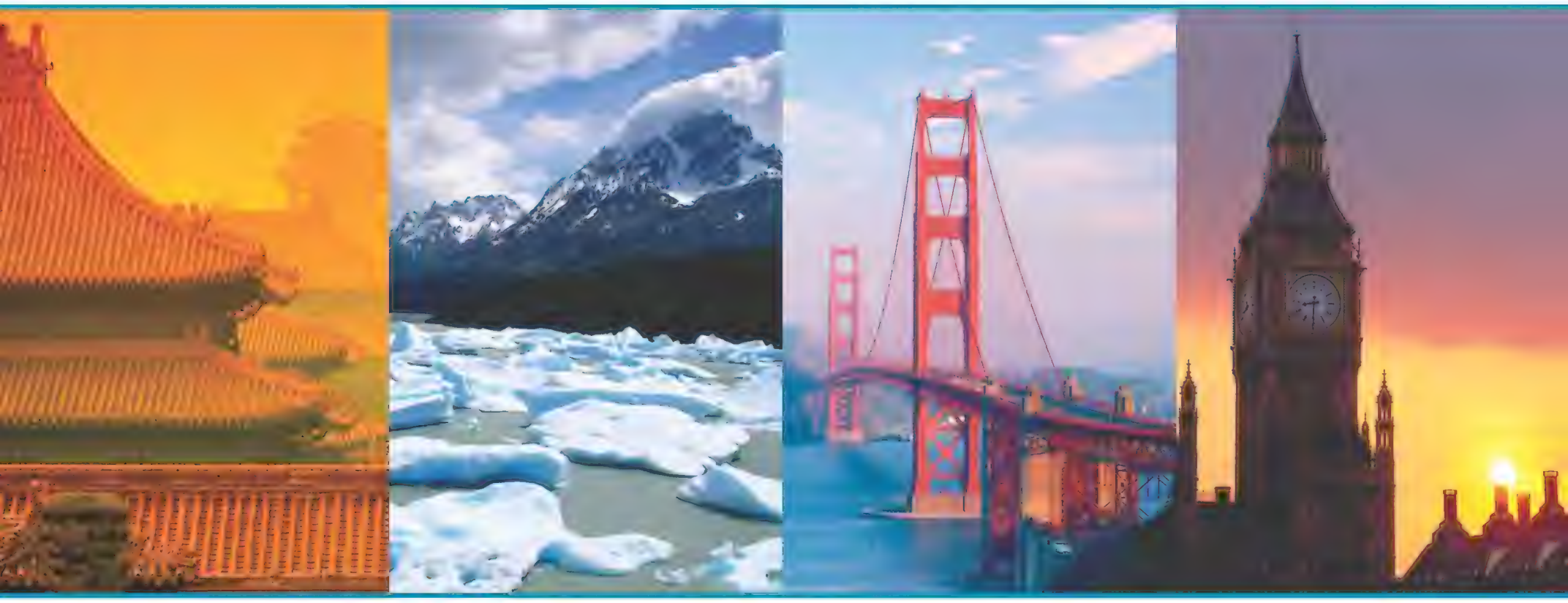

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Exhilaration, fear, surprise, and fun: spaceflight, according to the astronauts.

SPACE SHUTTLE DIARIES

To mark the 20th anniversary of the first space shuttle flight, we spent more than a year collecting reminiscences from those who have flown on the shuttle. Nearly a third of the 260-plus veterans shared their experiences with us. The resulting Smithsonian book, *Space Shuttle: The First 20 Years*, will be published by Dorling Kindersley this spring.

We asked the astronauts for their best stories, and they did not disappoint. Among their candid recollections, we hear about the momentary fear that grips a spacewalker when he pokes his head through an open hatch 200 miles above Earth, and the anxiety of landing a two billion-dollar spaceplane with the whole world watching. And we better appreciate how no two astronauts in those 20 years have had exactly the same experience. Here are just a few of their stories, excerpted by permission.

—The editors

Hello, Mir: STS-74 astronauts crowd Atlantis' *windows to peer at the Russian space station.*

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REACTION CONTR

Strapped on the front of a freight train

When the engines lit, I had no idea it was going to be that much energy, absolutely no idea. I've done catapult shots off of aircraft carriers and flown a lot of aircraft that have pretty good acceleration, but I have never felt anything like that. Within 30 seconds I was thinking this thing had better work, because if it doesn't, it's going to be really tough to turn that much energy in another direction. It's like being strapped on the front of a freight train going down the track at 100 mph. You feel all that mass and force behind you.

Mike Foale (center) and STS-84 crewmates head off for a practice launch. Below: Discovery *rockets into orbit (STS-102).*

The shuttle's empty fuel tank doesn't quite reach orbit—it falls back into the atmosphere and breaks up over the ocean.

The bear jumps off your chest Right before the main engines cut off, you feel like you have a bear sitting on you. It's three Gs. Then at the moment of engine cut-off, you go from three Gs to zero Gs instantaneously. The bear jumps off your chest, and you see your seat belts float upward, which is kind of cool. Then a couple of seconds later, you hear this big clang as the fuel tank comes off. That's actually a little startling to a first-time flier if you haven't been told about it, because the noise in the simulator isn't as loud as the real thing. When the tank comes off, it has a big, empty, metallic, clanging sound, and you're thinking, "Did we hit the tank or come off of it?" The other thing that can be startling is the first time you hear the primary Reaction Control System jets, the ones used to control the shuttle's position in space. The jets on the nose of the vehicle are like cannons going off when they fire. You hear this *boom, boom, boom.* **Jeff Wisoff**

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I'm not going back

I'm a scientist, not an astronaut, and I hadn't really planned on a shuttle flight. But in the 1970s I proposed to NASA to study fluid physics in space, and like any scientist I wanted to conduct my own experiment. So I was selected to fly as a payload specialist. I spent two years training, predominantly to run my own experiment, but also to run other experiments inside the Spacelab. And in 1985, my experiment and I finally flew on mission 51-B.

Everything was fine on the first day of the flight. I turned on everybody else's experiments and they worked wonderfully. But on the second day, when I turned on my own instrument, it didn't work. You can imagine my panic. I had spent five years preparing for this one experiment. Not only that, I was the first person of Chinese descent to fly on the shuttle, and the Chinese community had taken a great deal of interest. You have to understand the Asian culture. You don't just represent yourself, you represent your family. The first thing you learn as a kid is to bring no shame to the family. So when I realized my experiment had failed, I could imagine my father telling me, "What's the matter with you? Can't you even do an experiment right?" I was really in a very desperate situation.

A change-of-shift briefing inside Spacelab (STS-47).

I asked ground control if I could repair the instrument, and they were reluctant—for good reason. On a shuttle flight everybody's time is booked, and you don't have much free time to troubleshoot. And even though the shuttle is an engineering marvel, the ability to repair things is extremely limited. They have a couple of screwdrivers, a couple of wrenches, but it's pretty primitive. Plus, there were no real replacement parts.

I understood NASA's point of view, but I said, "Listen, I know the system very well. Give me a shot at it." They were still reluctant. So finally, in desperation, I said, "Hey, if you guys don't give me a chance to repair my instrument, *I'm not going back.*"

Well, NASA got nervous at that point. They actually got a psychologist to talk to the other crew members and ask, "Is Taylor going nuts?" Fortunately, my commander, Bob Overmyer, said, "No, he's okay. He's just depressed, and he really wants to repair the experiment. We'll help out." They were on my side. Finally NASA said okay, on a couple of conditions: first, that I wouldn't neglect my other responsibilities, and second, that I would quit after a reasonable effort.

I was relieved, because I hadn't really figured out how *not* to come back if they'd called my bluff. The Asian tradition of honorable suicide, *seppuku*, would have failed, since everything on the shuttle is designed for safety. The knife on board can't even cut the bread. You could put your head in the oven, but it's really just a food warmer. You wouldn't even burn yourself. And if you tried to hang yourself with no gravity, you'd just dangle there and look like an idiot.

I started the repair job. The only way to do it was to open up this large compartment and crawl inside. I lived inside the instrument for a day and a half, and the only thing my crewmates could see was my two legs hanging out. Meanwhile, they were fantastic—they took over all my housekeeping chores for me.

Luckily I was able to solve the problem and resume the experiment. Emotionally, I went from the bottom of the ocean to the top of the mountain. And once it was fixed I was so high I couldn't sleep. I just worked around the clock. The results turned out to be very good—in fact, we're still using data from that flight more than 15 years later.

No, you're not going to fall

Having been in space for about five days before my first spacewalk on STS-63, I considered myself pretty acclimated to the environment. But when I opened up the hatch to come out of the airlock, I got a face full of Earth. We were flying upside down, so I immediately saw the grandeur of Earth down below, and I had two sensations. The sense of movement was striking. It made me feel dizzy to see Earth moving by at 18,000 miles per hour as I peered out this small aperture I was about to emerge through. I got a little uneasy and a little dizzy, and I didn't get that from looking out the shuttle window.

Then, as I was getting ready to step out of the spaceship, it felt for an instant like gravity was going to grab hold of me and pull me down toward Earth. Being a scientist and an astronaut, you know that's not going to happen. But within a split second I had those two sensations. Your natural response is to hesitate and grab on harder. I felt myself hanging on to the handrail and saying, "No, you're not going to fall toward the Earth—this is the same thing you've been seeing for the last five days." Then I was able to go out and enjoy the view.

Above: Refurbishing the Hubble Space Telescope (STS-82). Below: Jeff Wisoff reenters Discovery *(STS-92).*

The pilot lines up for a landing (STS-51D). The shuttle's giant Vehicle Assembly Building is visible out the right-hand window.

Nailing it I remember during my first landing how heavy I felt, just the helmet and suit and everything, on returning to normal gravity. On my third flight, when I was commander for the first time, I didn't feel a thing, the adrenaline was pumping so hard. I mean here I am, landing this two-billion-dollar spaceship. You can't screw up.

You talk about analyzing things down to a gnat's hair. That's how your landings get looked at when you get back on the ground. The engineers tear it apart. Before launch I told Al Hochstein, the guy in charge of that analysis, "Al, I'm gonna nail it, okay?" With a heavyweight orbiter like we had on STS-65, we normally land at 205 knots [235 mph]. But I said, "I'm gonna land at 200 knots, because slow is better than fast." And I landed at 201 knots. When Al came back with the debrief charts after the mission, he had this nail with a hammer coming down on top of it. ***Bob Cabana***

All over with After we landed, we went back to crew quarters so the flight surgeons could get some bodily fluid samples for research purposes. I was talking to the flight surgeon in my flightsuit and tennis shoes. He asked if I wanted some lemonade, and they brought me a little Dixie cup. I'm sitting in a chair, my forearms on my knees, and I reached down to take my shoes off. But before I did, I released my cup without giving it a thought, because I expected it to float. And of course, as soon as I did, it fell right to the floor. We both just sat there and laughed, and I thought to myself, *Well, that's all over with now.*

Endeavour *makes a night landing in Florida in January 1996 (STS-72).*

How Things Work:

Flying U

by Patricia Trenner | *Illustrations by John MacNeill*

Gravity and other forces conspire against conventional flight, but they are positively Machiavellian about inverted flight. Pity the first pilot who rolled inverted and sailed blithely along, only to hear the engine cough and die of fuel starvation when the gas settled in the top of the tank, or have the engine seize when the oil did likewise.

Engineers and designers have conspired in return. Here are a few devices that enable inverted flight and transitional maneuvers, or at least make them less of a struggle.

Inverted fuel systems

Most aerobatic airplanes with inverted fuel and oil systems use fuel injection rather than a carburetor. When a carburetor is inverted, it can no longer meter fuel, and the float rises and cuts off the incoming supply. A fuel injector, which doesn't care what attitude it is in, measures airflow and meters the proper ratio of fuel to each cylinder so that each receives a constant flow of the same fuel-air mixture.

To ensure the flow from fuel tank to fuel injector, aerobatic aircraft with the fuel tank in the fuselage have a "flop tube," a flexible hose with a weight in the free end, plugged into the fuel tank. In normal flight, the weighted end of the hose flops to the bottom of the tank and draws fuel from there. When the airplane rolls inverted, the weighted end flops to the top of the tank (❶ in Figure 1), with the fuel. Regardless of the aircraft's attitude, fuel and flop tube end up in the same spot.

Aerobatic airplanes that have fuel tanks in the wing use a small "header tank," which is connected to the wing tanks. In normal flight, fuel gravity-feeds down to fill the header tank, which is connected to the suction side of the fuel pump. When the airplane rolls inverted, the header tank is now above the engine, and fuel gravity-feeds from the header tank to the fuel pump. A check valve in the line from the main tank to the header tank stops fuel from draining back into the main tank when the airplane is inverted.

Inverted oil systems

Engines that use an external oil tank—"dry sump" engines—have a device similar to a flop tube that can reach oil in almost any attitude. In wet sump engines, in which oil is stored internally in a sump at the bottom of the crankcase, an oil pickup line near the top of the engine ❷ as well as in the oil sump ensures that oil is available in any attitude. A valve with two steel balls separated by a spring is connected to the top and bottom of the engine; like a flop tube, the balls (and the oil) go where gravity dictates, alternately covering and opening the appropriate oil pickup point.

Symmetrical Wings

Most airfoils are cambered, or curved, on top but flat on the bottom. As a result, they fly better upright than inverted. Symmetrical airfoils, which have the same curvature on both surfaces (❸ in Figure 2), perform exactly the same upright or inverted, and so are favored by aerobatic pilots. In order to fly at all, however, a symmetrical airfoil must be positioned at a slight pos-

Leo Loudenslager made inverted flight an art form.

CAROLINE SHEEN

pside Down

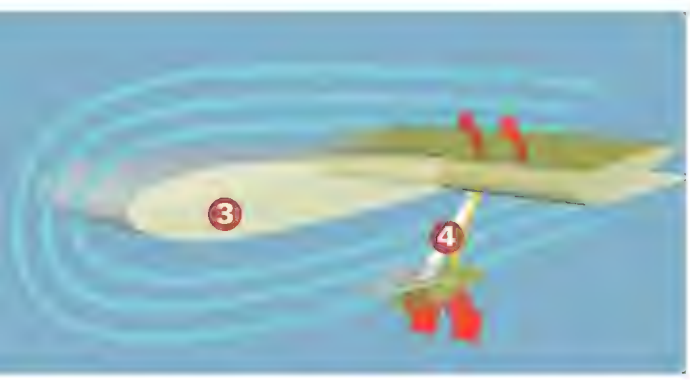
itive angle—leading edge high—with respect to the flight path; otherwise the airflow around the upper and lower surfaces would be the same, and no lift would be created.

Aileron spades

These shovel-shaped surfaces, rigidly mounted on arms forward of the ailerons, provide "aerodynamic balance," reducing the effort needed to roll the airplane. Aerobatic airplanes need aerodynamic balances because their control surfaces are large and their speeds are sometimes high. When the ailerons are neutral, the spades are aligned with the airstream and do nothing. But when an aileron is deflected upward, for example, its spade tips downward. Air presses against it, ❹ helping the aileron along, just as the weight of a small person on one end of a teeter-totter helps a larger person at the other end push off the ground. The farther the aileron is deflected, the larger the force supplied by the spade. Aerobatic pilots describe spades as akin to power steering.

"Spade design is a black art," says airshow pilot Patty Wagstaff. "You see all kinds of shapes and all sizes, depending on the airplane. Akro pilots are always tweaking them to get the control feel just right—not too light and not too heavy. I've flown without spades, and it was like driving a Mack truck."

Figure 2



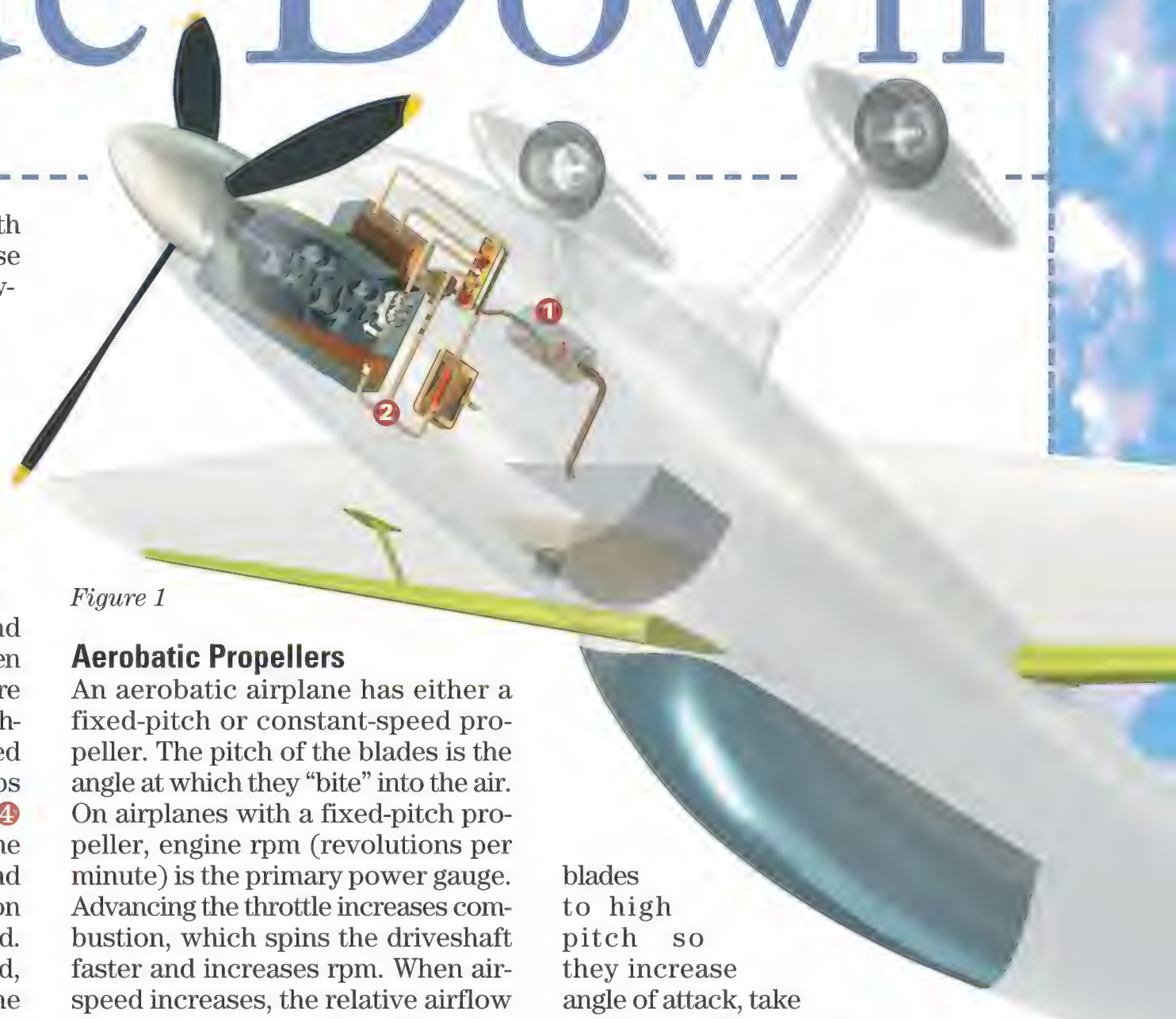


Figure 1

Aerobatic Propellers

An aerobatic airplane has either a fixed-pitch or constant-speed propeller. The pitch of the blades is the angle at which they "bite" into the air. On airplanes with a fixed-pitch propeller, engine rpm (revolutions per minute) is the primary power gauge. Advancing the throttle increases combustion, which spins the driveshaft faster and increases rpm. When airspeed increases, the relative airflow from the airplane's forward motion reduces the angle of attack for a given pitch of the propeller blade, which reduces drag and lets the propeller spin faster. Too much airspeed can result in engine overspeed, so the pilot must keep an eye on the tachometer to make sure engine rpm does not exceed redline.

On a constant-speed propeller, which has been likened to a car's automatic transmission, blade pitch is adjusted by a governor, an engine-driven pump that monitors engine rpm and uses oil pressure to vary the pitch of the blades to maintain that rpm, regardless of changes in airspeed or power settings.

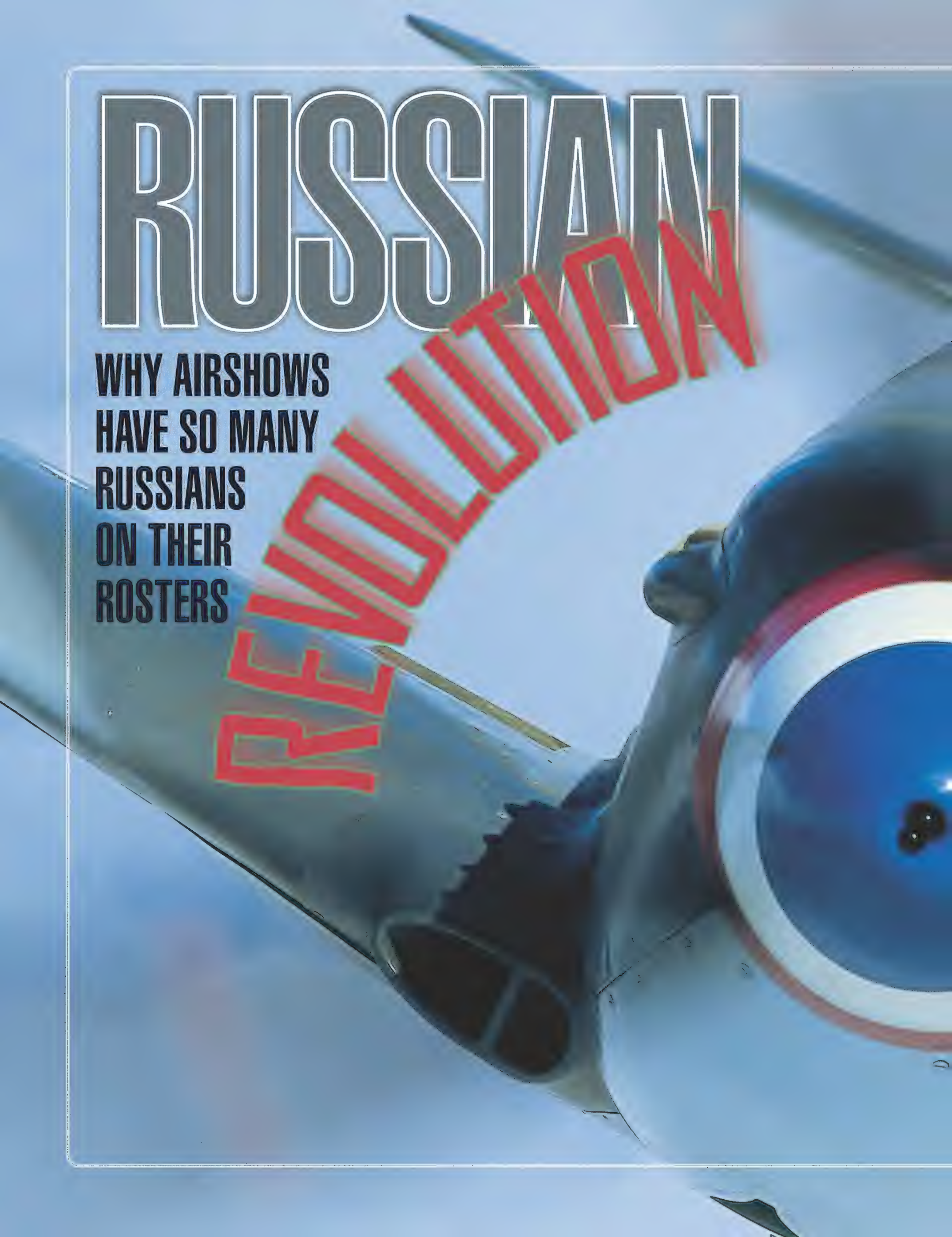
At high rpm, the blade pitch is low—taking a smaller bite of the air and decreasing angle of attack—and the prop wants to spin faster. To reduce rpm, the governor moves the blades to high pitch so they increase angle of attack, take bigger bites of the air, and slow the engine down.

If there is a loss of oil pressure in the governor, a constant-speed propeller will go to low or "flat" pitch (knife edge to the airflow), the blades will encounter no air resistance, and the engine will consequently overspeed.

An aerobatic constant-speed propeller has a large counterweight on each blade root. If engine oil pressure to the governor is lost in zero-G or negative-G manuevers, the centrifugal force of the counterweight drives the blade to high pitch—the maximum surface area is presented to the airflow—and the engine "underspeeds," which prevents any overspeed damage. Throughout an airshow performance, you will hear a howl from the propeller as the blades shift.

RUSSIAN REVOLUTION

WHY AIRSHOWS HAVE SO MANY RUSSIANS ON THEIR ROSTERS



BY DEBBIE GARY

Last spring at the Langley Air Force Base airshow in Virginia, the weather staged an unexpected grand finale, starring retired Brigadier General Steve Ritchie. Flying a McDonnell F-4D Phantom, the fighter in which he became a Vietnam War ace, Ritchie was called upon to pit his talents against a sudden storm that thundered onto the airfield like an army of Cossacks, upending tents, hurling signs, and knocking the daylights out of any airplane or pilot left on the ramp. His was the last daytime act. Later, after the storm had galloped out of striking distance and blackness swallowed the airfield, a MiG-17, Ritchie's nemesis during the war, stole the show.

Bill Reesman flew the one-of-a-kind, pyrotechnic Russian jet act. His *Red Bull* MiG, a shark's fin between boomerang wings, became thousand-foot snakes of fire chasing a flickering peephole of an afterburner through the dark. The show, visible for 30 miles in clear air, is fiery enough to throw a city into panic and jam the circuits on a 911 switchboard. Meanwhile, Julie Reesman, his wife and narrator, told the audience tales of MiG history and adventures.

In 1947, the MiG-17's predecessor, the MiG-15, started life in the Mikoyan Gurevich Design Bureau as Project S, for *strelovidnost*, or "swept" wing. It first took U.S. pilots by surprise in November 1950 over North Korea. Using captured German technology and copied British Rolls-Royce Nene jet engines with huge centrifugal compressors, the MiG-15 met the Kremlin's demand for a high-altitude day interceptor able to take off from rough grass strips and reach speeds of up to Mach 0.9. By the time U.S. fighters faced another enemy in the

The Yak is back: Steve Barber zooms in with a Yak-3UA, one of only eight of the fighters newly manufactured by Yakovlev in the 1990s.

JOHN M. DIBBS/PLANL PICTURE COMPANY

KATSUHIKO TOKUNAGA (2)

Russian craft are hits all over: In Italy a Sukhoi showboats. At home, Paul Entrekin (right) and Holmes Patton dig the MiG.

Vietnam War, it had evolved into the faster, more powerful, more maneuverable MiG-17.

Reesman, a Vietnam veteran who flew 320 missions in F-100s and has 550 hours in the -17, says, "Now that I know how great this plane is, I am happy I never met one in Vietnam, because there is a good chance he would have had me for lunch. The turn radius, the acceleration, and the performance are spectacular."

The MiGs, once our enemies' aircraft, are among our favorite entertainers on the American airshow circuit, and Reesman is one of a growing number of airshow pilots who have fallen in love with them and other Russian and Eastern Bloc airplanes. At the Langley airshow, two other Eastern airplanes performed: Dan McCue's sleek, Czech-built Aero Vodochody L-39 jet and Sean Carroll's Yak-9U-M. On static display were Yak-52s and the Chinese-built Nanchang C-J6A. At other shows the lineup includes Zlin 50s; Sukhoi Su-26s, -29s, and -31s; Yak-9s, -11s, -50s, -54s, and -55s; L-39 teams; and multiple MiGs. The acts have names like Russian Thunder, Mr. MiG, Tumbling Bear, Red Stars, Red Storm, and Red Threat.

Eastern Bloc machines began their infiltration even before the 1991 disbanding of the Soviet Union. By the mid- to late 1980s, several enterprising Americans had tapped a line into the Soviet aviation network. In 1986, retired Marine instructor pilot Paul Entrekin bought a Chinese MiG-15 out of a crate on a California dock and helped compile test flight data for U.S. certification. Entrekin planned to develop an airshow act around the airplane.

"The manuals we got were Russian translated to Chinese translated to English," he remembers. "They read like comic books." He and Bruce Goesling, a broker and restorer of retired military jets in Chino, California, flew the MiG to establish the performance data and write the flight manuals the Federal Aviation Administration needed to certify the airplane to fly in the Experimental/Exhibition category in the United States. "The Department of Defense actually already had all the numbers we needed," says the 47-year-old Delta Air Lines pilot, "but the information was classified and they wouldn't give it to us."

By the summer of 1987 Entrekin was flying his MiG at airshows, but not without a few problems. He was treated rudely on occasion by diehard types who still considered the Soviet Union the Evil Empire. It didn't help that even when he was on the ground he wore a Russian flightsuit and stayed in character—speaking with a fake Russian accent, sometimes communicating with reporters through a friend acting (literally) as his interpreter. Worse, some in the airshow establishment still distrusted all things Russian, and whispers found their way to insurance underwriters that Soviet airplanes were exploding bags of bones. In an act of great daring and faith, Entrekin took the MiG on the airshow circuit for two years before he could get any insurance. The crowds loved seeing an authentic Russian fighter. And Entrekin found the MiG safe, reliable, and trouble-free. By his fifth airshow season, he had affordable insurance and as many shows as he could fly. And he had blasted the route for other airshow pilots to follow.

In 1988, Brian Becker, an aircraft dealer from Pompano Beach, Florida, brought the revolutionary Sukhoi-26 to a San Diego airshow for a sneak preview, with U.S. aerobatic champion Clint McHenry at the controls. The next year, at the Experimental Aircraft Association's annual convention in Oshkosh, Wisconsin, Becker created a sensation with the Russian champions flying the Su-26. No one who was there has yet forgotten seeing the Sukhoi vertical roll as fast as a steel bit in a power drill, halt in midair, hang there on the prop, rotate 90 degrees on its horizontal axis, then trundle sturdily forward. The Russian aerobatic pilots had worked hand in hand with designers and the government, combining their focused ambition and uncanny skills with the Sukhoi Design Bureau's advanced technical knowledge and the Kremlin's bullish commitment to give their cham-

pions whatever it took to win. What emerged was the greatest aerobatic airplane in the world.

Brian Becker went on to create a worldwide dealer network. From 1990 to 1996, Becker took everything that Little Sukhoi (as opposed to the fighter division) produced. That was 24 airplanes a year. They were not only the dancingest aerobatic machines a performer could fly, but in the early 1990s they were also the most affordable—$155,000 in a marketplace of $200,000 Extras and CAPs. And their construction was unique. Tom Lang, who sells the airplane in the States, says, "The airplane should probably cost two times the $250,000 that it costs now. The landing gear is titanium—that alone is worth $150,000—and the fittings are titanium. Titanium is strong as steel but light as aluminum. The plane should have been hideously expensive, but Russia's got 95 percent of the world supply of titanium."

Airshow pilots who wanted to master the -26 trained with Russian coaches. In 1993, John Piggott, a friendly, 50-ish pilot now taking a break from airshows, bought the first Su-26 on the West Coast. He was a seasoned Pitts pilot before he flew the Sukhoi the first time, but that flight, with Sukhoi test pilot Yevgeny Frolov, typified most American experiences. "He flew humpty bumps with rolls up, rolls across, and rolls down on the humpty line," he recalls. (A "humpty bump" is a vertical line up, a convex curve over the top, and a vertical line down.) "Then he turned the stick over to me. I started a loop and suddenly he grabbed the stick. *What the heck?* I thought there must have been traffic I didn't see."

After the same thing happened twice more, the amiable Piggott started to get a little steamed until the Russian reassured him he had not taken the stick from him, even though the airplane's response made Piggott think he had. The Sukhoi's controls are so light that what Piggott considered a normal amount of back pressure to loop the airplane caused it to snap roll, a wild gyration that occurs when one wing is flying and the other is stalled. For the next six years he trained with Russian coaches three times a year.

Airshow pilot Ian Groom now has close to 2,000 hours in his Su-31, a lighter single-seater without the tubular steel frame of the -26 and wing tanks for more range. "You only begin to appreciate the brilliance of the design and the robustness of the construction after you've got 500 hours flying time in it," he says. "You can do things that are aerodynamically unbelievable, like having the whole airplane stalled out of control but a tiny piece of the tail is still flying, and that piece is enough to maneuver the whole machine."

A Pratt & Whitney-powered Yak-11 may have been the first Russian to fly at a U.S. airshow. It belonged to Dan McCue, today a performer with the Northern Lights aerobatic team, and he flew it at airshows between 1984 and 1989. (McCue's friend, the late Bob Yancey, bought a Yak-11 from a dealer in France, who, learning that the Egyptian air force had surplused their fleet, bought all 41 of them. Yancey put a Pratt & Whitney R-2000 engine in it, named it *Perestroika*, and raced it at the Reno Air Races in 1981. McCue bought his from the same supplier.) The -11 is a two-seat trainer in the famous fighter series begun in 1940 with the Yak-1. The series reached perfection in late 1943 in the elegant, agile Yak-3, but an earlier version, the Yak-9, was produced in far greater numbers. The -9 had most of the series improvements and is the Russian coun-

GREG L. DAVIS (2)

Bill Reesman says he prefers his MiG-17, in which he performs at speeds approaching 600 mph, to the 50 other types of aircraft he has flown. Top: Trailing smoke from underwing pods, Reesman's MiG skims along the Atlantic Coast.

MICHAEL HABERLIN

Bud Granley fell head over heels for the Yak-55. Fans see what he calls "slow-motion magic" in tumbles and rolls.

Opposite: Eddie Andreini and his Yak-9U-M at play over Half Moon Bay, California.

Below: Since 1993 Bob Davis has been performing day and night in the two-seat Sukhoi 29.

terpart of the American P-51, the British Spitfire, and the German Messerschmitt Bf 109. The Russians threw almost 17,000 of them at the Germans; not one is flying today, and only four are on static display, one at the Champlin Fighter Air Museum in Mesa, Arizona. No original Yak-3s fly either, and warbird watchers know of only three in museums.

Warbird buffs will dive on coral reefs, tramp through steaming jungles, and dig below the Greenland ice cap in pursuit of World War II prizes. Two U.S. businessmen saw an easier way to supply a unique market. Air racer Alan Preston jump-started a deal with the Yakovlev design bureau in 1991 to remanufacture the Yak-3. Of the resulting eight Yak-3UAs, six are flying in the United States.

In 1989, Jim Wickersham, who had been flying shows in MiG-15s, -17s, and a Yugoslavian jet, the Soko Galeb, began doodling Yak-9 design improvements on the back of a napkin. Today Wickersham manufactures a new version of the Yak-9 in central Russia. Longtime airshow pilot Eddie Andreini bought one, Wickersham's first, in 1997. He painted it red, put a lightning bolt on the sides and yellow stars on the wings, tail, and fuselage, and named it *Barbarossa*. "The lightning bolt is a Russian good luck charm," Andreini explains, "and Operation Barbarossa was the code name of Hitler's massive blitzkrieg attack on the Russian front in June 1941."

CAROLINE SHEEN

In 1988, Yak-11 owner Dan McCue, who has flown for Delta Air Lines for 35 years, most of them on flights to Eastern Europe and Russia, was invited by Czech historians to the national aviation museum in Prague. They showed him an Aero Vodochody L-39, mounted on a pedestal in the museum. "I have to have one of those," he said. Impossible, they said. Civilians can't own them, only governments. "But you don't understand," he said, "in America, a lot of civilians own military airplanes. Where can I buy one?" No, no, no, they said.

The Czechs built 3,000 L-39s and exported 2,000 to the Soviet Union. By the time the Communist regime fell, many of the L-39s had been surplused and acquired by Soviet air clubs. So McCue met with officials at the military air club in Moscow. "They were flat broke," he says. "They didn't even have funds to buy coffee. But they did have a lot of L-39s sitting on the ramp, so I negotiated for the best one."

It was a little risky in the beginning. The deal went like this:

"I want the airplane."

"We would like to sell it to you, but we have no money to even take the airplane apart and put it in a box, get it on the rails, and ship it. Give us the money first."

"No."

The problem, according to McCue, was that in 1991, "there was no means of connecting with them from a business standpoint, no banking systems. You couldn't wire money or write a check. The only way you could send money was to put it in a box and hand it to them. So finally I looked them in the eye and said, 'This is simple. Be good to me and I'll be good to you. This is what I'll do for you. I will buy the airplane and I will give you the money in advance, which is a bad business decision. I want the airplane in less than six months and I want it complete and able to fly.'

"I gambled and I won. I got the airplane and there couldn't have been nicer people to do business with. So, I opened the door and there was nobody else there until maybe four years later."

McCue knew that others would be interested in buying the aircraft, if only they knew about it. He took his jet on the airshow circuit. "I went out there like a used-car salesman. 'You won't believe it; this is the best civilian-owned airplane you can buy,' " he told prospective customers. " 'It is low maintenance, low on fuel, and it is a Mach-0.8 airplane. It is pressurized, has air conditioning. You can fly it at

CORNELIUS BRAUN

JOHN BAERT

Dan McCue was the first to bring the Aero Vodochody L-39 jet trainer to the United States. Below: Paul Entrekin's MiG-15 was the first Russian fighter to fly at U.S. airshows.

KATSUHIKO TOKUNAGA

23,000 feet without an oxygen mask and can fly it off a 2,000-foot grass strip.' "

About the same time, former airshow pilot Mira Slovak went back to the Czech Republic for a visit and to buy some L-29 Delfin trainers. While he was there in the early 1990s, he discovered some perfectly good Zlin 50s about to be destroyed. The Zlins, which take their name from the town in Czechoslovakia where they were built, are aerobatic monoplanes that won the World Aerobatic Championships in 1984 and 1986. "Why are you destroying them?" he asked. Because it is a regulation. "How many hours do they have?" Nine hundred. "900 hours is a new airframe in America," he told them.

The airplanes had belonged to the Czech aerobatic team, and the maintenance crew had followed strict procedures: At 300 hours of flying time, the aircraft went back to the factory for an overhaul; same thing at 600 hours. But at 900 hours officials declared that the airplane was used up and had to be destroyed. The 900-hour airplanes were in excellent shape, however, so Slovak bought two. Rob Harrison has been flying one for the last eight years with his Tumbling Bear airshow act and has had no significant maintenance problems.

Anyone who owns, operates, or maintains an Eastern Bloc airplane raves about it. "Bulletproof" they call it, meaning the craft is well constructed, easy to operate, and easy to maintain. Atlanta airshow pilot and mechanic Larry King owns a Russian Technoavia SP-95, a low-wing aerobatic aircraft, and works on a lot of Sukhois and Yaks. He says: "Every Russian airplane is designed with two things in mind—to be serviceable for the conditions and to be maintained by the lowest-level-skill person.

"All Russian airplanes are similar under the skin," he continues. "They have the same engine, the same systems, the same radios, even the same control systems, the same tall control stick, the same sight picture [what the pilot sees from the cockpit], the same instrumentation, and even similar operational speeds."

The engines are Vedenyeev M-14Ps, nine-cylinder radials with 360 to 420 horsepower; instead of the cowl flaps used on Western aircraft, they have gills inside the front of the cowling that can shut out all but the tiniest trickle of Siberian winter air. Their sound is their signature. It is more Harley-Davidson than Honda. While high-revving American six-cylinder opposed engines squeal and whine like chimpanzees, the big, torque-y, slow-turning radial M-14s growl and roar like gorillas. The Zlins use American-made Lycoming engines, but the Yaks, Sukhois, SPs, and Nan-

MiG RIDE

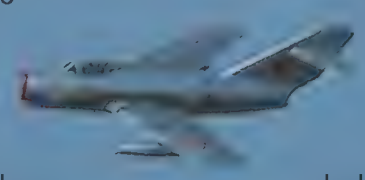
On the ramp at the Tamiami Airport in front of the Wings Over Miami Museum, Tom Righetti's F-86 Sabre and MiG-15UTI sit nose to nose, two snub-nosed, muscle-bound fighters sizing each other up. I size them up too, focusing on the MiG because I'm about to get a ride in it.

I climb onto the wing and into the back cockpit, and airshow performer Dale Snodgrass talks me through my cockpit checks and shows me how to close the rear canopy. Snodgrass is famous, and not only for having the most hours logged in an F-14 Tomcat. I've seen him fly a lot of airshows; pilots always marvel at his grace.

As he straps in, I copy words in my notebook from the panel: reflektor, podwozie, schowane—all in Cyrillic. I am out of my league, but I am in heaven. I've flown jets, but never a fighter.

An honest airplane talks to you all the time like an old friend. The L-39 does that. John Murphy let me fly his a couple years ago. I looped, rolled, and, with Murphy's coaching, made the landing. The jet whispered to me the whole time, "I'm a trainer, you can trust me." Larry King's Technoavia SP-95 was a little more exotic, so I took it slow, repeated every move a dozen times, and made corrections. "You could learn to fly me," the airplane said.

But the Sukhoi 29 slapped its knees and laughed at me. One fast move to full left or right stick deflection and I was off balance, the sky a blur. When I brought the stick back to center to stop the roll at the wings-level position, the airplane jumped side to side like a Russian dancer bouncing on his heels, kicking his feet out in front of him.



The MiG-15 isn't that unstable, I know. I expect the feel of an airplane with high wing loading, high sink rates, and a slow reaction to power changes. I expect the roll rate to change at different speeds. "The sweet spot," Snodgrass tells me, "is between 170 and 400 knots. That's where its flying qualities are the best."

MiG pilot Tobe Gooden had told me, "When I was in Vietnam they used to tell us that if we got the MiGs to chase us at 500 knots we could shoot them down. And sure enough, one day I got mine up to 520 knots on the deck and it was just like the stick was set in concrete. It has got a little bitty elevator with no hydraulics helping you, so it feels like being in a car when you lose power and can't use the power steering. I couldn't even move the controls until I got back down to 450."

The fighters line up side by side on the runway. From the Sabre, Righetti nods then disappears ahead to our right. Snodgrass holds the brakes, adds full power, then smoothly accelerates. As soon as we lift off, he turns to cut inside the Sabre for a formation rejoin. Every movement of the stick is as smooth as I had expected.

In the back seat I watch our speed climb toward 230 knots. Then: the surprise.

When Snodgrass closed his canopy before the flight, we could not tell that it had jumped off its right front hinge. The front canopy can be unhinged and lifted off from the right side for maintenance and locks shut on the left. Before we taxied, it was sealed and locked tight, a perfect looking fit. As we neared 230 knots, the right side of the canopy began to lift. I did not know this, but felt a giant hand slap us as the airflow pried the front canopy off and flicked it end over end past my cockpit. Somewhere in the Everglades three fishermen are on a cell phone reporting a somersaulting canopy.

I'm hanging onto my helmet, my sunglasses, and the flapping pages of my notebook. Righetti is on our right wing in his F-86 checking our wings, fuselage, and tail for nicks. By the tone of Snodgrass' voice, I gather he is talking to me, but I can't hear his words. "I'm okay," I say, but actually I feel like a scrawny-necked goose in a hound dog's jaws.

Snodgrass methodically experiments with different speeds, different configurations. From the back seat I can feel the air nibbling at the wing when he slows to 170 knots. It feels skittish and slow, so he speeds back up to 180 knots.

The pressure of the wind roaring into the cave of the back cockpit is like dirt being packed into a hole. I can suck in air, but my neck is in a vise grip. I stay calm by focusing my mind on one continuous picture, which becomes real soon enough: a perfect touchdown, a smooth rollout, and a taxi in to waiting friends.

—Debbie Gary

changs all use the radials, and they use compressed air for starting.

Compressed air in the cylinders gets the engine turning without a big power drain. Cranking an engine with a starter, a battery, and a crankcase load of cold, congealed oil is a huge power drain; introducing nitrogen compressed to 750 pounds per square inch, which is drier than ordinary air, into individual cylinders in sequence pushes the pistons down and starts the engine running without internal or external electrical power. It is a brilliant solution to the problem of harsh Russian winters.

The older airplanes, the MiG-15s, MiG-17s, and military Yaks, also used compressed air to operate the landing gear brakes. The pilot squeezes a lever on the control stick and pushes individual rudder pedals to select one or both sets of brakes on the wheels. Modern airplanes, like the Su-26 and the Yak-54, which are built for export, use Western-style hydraulically operated brakes. Tobe Gooden, a 58-year-old Continental Airlines pilot who spent 21 years flying for the U.S. Air Force, flies his MiG-15 at airshows and describes his experience with the pneumatic brakes this way: "It is the only part of the airplane that isn't built like a tank. They're like bicycle brakes on the handle bars. When you press the stick it blows up two tubes on each wheel and presses the puck against the brakes. There are no hydraulics, no mechanical leverage, just what you can squeeze out of it. The excess air gets dumped overboard."

MARK SCHAIBLE/EAA

Ian Groom performs 20 consecutive snap rolls in his Su-31, which has a roll rate of more than 400 degrees per second.

Another disadvantage is that when there is a leak in the pneumatic system, like one that Paul Entrekin had in 1993, no tell-tale red hydraulic fluid pools on the ramp below the leak. When Entrekin landed after performing his last show that November at Naval Air Station Pensacola, he turned off the runway and lost his brakes and steering. The metal gadget that holds the brake pucks in place had broken, and its jagged edge had pierced one of the pneumatic bladders. Without pneumatics, he was a bowling ball on the loose, and six glittering Blue Angels jets stood like pins directly in his path. Luckily NAS Pensacola has a ramp the size of Siberia, and Entrekin coasted to a stop without striking anything.

Bud Granley flies both the Yak-55 and the Yak-52 on the airshow circuit. The single-seat -55 debuted at the 1982 World Aerobatic Championships and was to be a top competition machine before the Sukhoi-26 replaced it. The Yak-52 is one of the best trainers on the planet. Granley and his son Ross, formerly a pilot with the Royal Canadian Air Force Snowbirds demonstration team, fly a formation act with two Yak-55s, and Granley raves about the craft's performance: "It flies so slow and does so many things that it looks like a radio-controlled model airplane doing stuff." It's true: Audiences are accustomed to watching high-speed, high-performance airplanes zipping on and off stage, but when a high-performance airplane can do its whole act at 120 knots or less, as the Yak-55 does, the show looks like it is taking place on a wide-screen television in front of crowd center. It is big, slow, and revolutionary.

If someone bigger than all of us orchestrated a party to celebrate the launching of this revolution, he would have planned exactly what happened during the summer of 1991. Chuck Newcomb, a former Blue Angel who puts on the Cleveland, Ohio airshow, organized a well-planned, much publicized six-city airshow tour featuring two ultra-modern MiG-29s flown by handsome, young, personable, thoroughly Russian test pilots from the Mikoyan Design Bureau. After two months of planning, the MiGs and their transport chase plane left Moscow, crossed Siberia, and headed for Alaska. Newcomb had a Cleveland television crew waiting for them at Elmendorf, near Anchorage, because it was to be a great celebration. But while they were airborne the trip took a historic turn. Tanks rolled into Moscow and the Soviet Union began to tumble. "[The event] was already a two-headed cow," Newcomb says, "but now it became the biggest two-headed cow in the world. I thought about all those hours I sat in military ready rooms doing aircraft identification, then flying up and intercepting Russian Bears and flipping them the bird.... Now we were going to get up close and personal with them and they were going to fly those airplanes for us. Then it turned into something grander in scope because—guess what?—the wheels fell off the Soviet Union." The tour was delayed when, as a result of those events, the U.S. government required renewed clearance.

Finally the flight got under way. The night before the MiGs arrived in Cleveland, huge crowds of spectators began to gather around the perimeter of the city's Burke Lakefront Airport. People wanted to be present for history.

Now that starry-eyed wonder is gone. Russian, Czech, Polish, Chinese, Romanian, and Hungarian airplanes have been absorbed into the American airshow scene, just as whole neighborhoods of Asian and European families have become part of our cities and our nation. Airshow promoters, who in the late '80s and early '90s rushed to hire the Russian airplanes, no longer care about their origins, only how they are flown. Groups of MiG pilots appear at trade shows and flocks of Yak-52s gather to practice formation flying. But the airplanes that once inspired a half a city to gather in the dark and wait have lost that magnetism. Now they are merely rugged, reliable, beloved airshow performers.

OPPOSITE: MARK SCHAIBLE/AVIATION-PHOTO.COM

Opposite: It is no longer rare to see Yak trainers and their Chinese cousins—Nanchang CJ-6As—flying formation; the Yak Pilots Association has 300 members.

The sensitive Sukhois take getting used to, as John Piggott found the first time he tried a loop.

BRIAN BECKER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Best of Seven | Boeing B-29

Of the 3,970 B-29 Superfortress bombers built by the Boeing Company and its licensees during World War II, only one—*Fifi*, owned and operated by the Confederate Air Force (recently renamed the Commemorative Air Force)—is airworthy and doing the airshow circuit. If Tony Mazzolini and about 700 volunteers at Boeing's Wichita plant have anything to say about it, *Fifi* will soon have company.

Mazzolini, a Continental Airlines employee, had perhaps a hundred hours as a flight engineer aboard Superfortresses while he was in the Air Force. About 20 years ago, a friend told him about the Confederate Air Force and suggested that it could use Mazzolini's skills. He launched a local wing of the CAF, from Cleveland, his hometown, and the group met to decide on what kind of aircraft they would restore and operate. They knew multi-engine airplanes would earn them the most revenue at airshows, and, as he recalls it, "Someone in back said, 'How about a B-29?'" Mazzolini spent the next four years making phone calls in search of a B-29 they could rebuild, but every lead came up dry.

In 1987 he found his bomber. Since being retired from operational service in 1956, a B-29 named *Doc* had been sitting in the desert at China Lake Naval Air Station in California, where it had been designated for use as a target for weapon tests.

The airplane took its name from the painting on its nose depicting one of

BOEING ARCHIVES

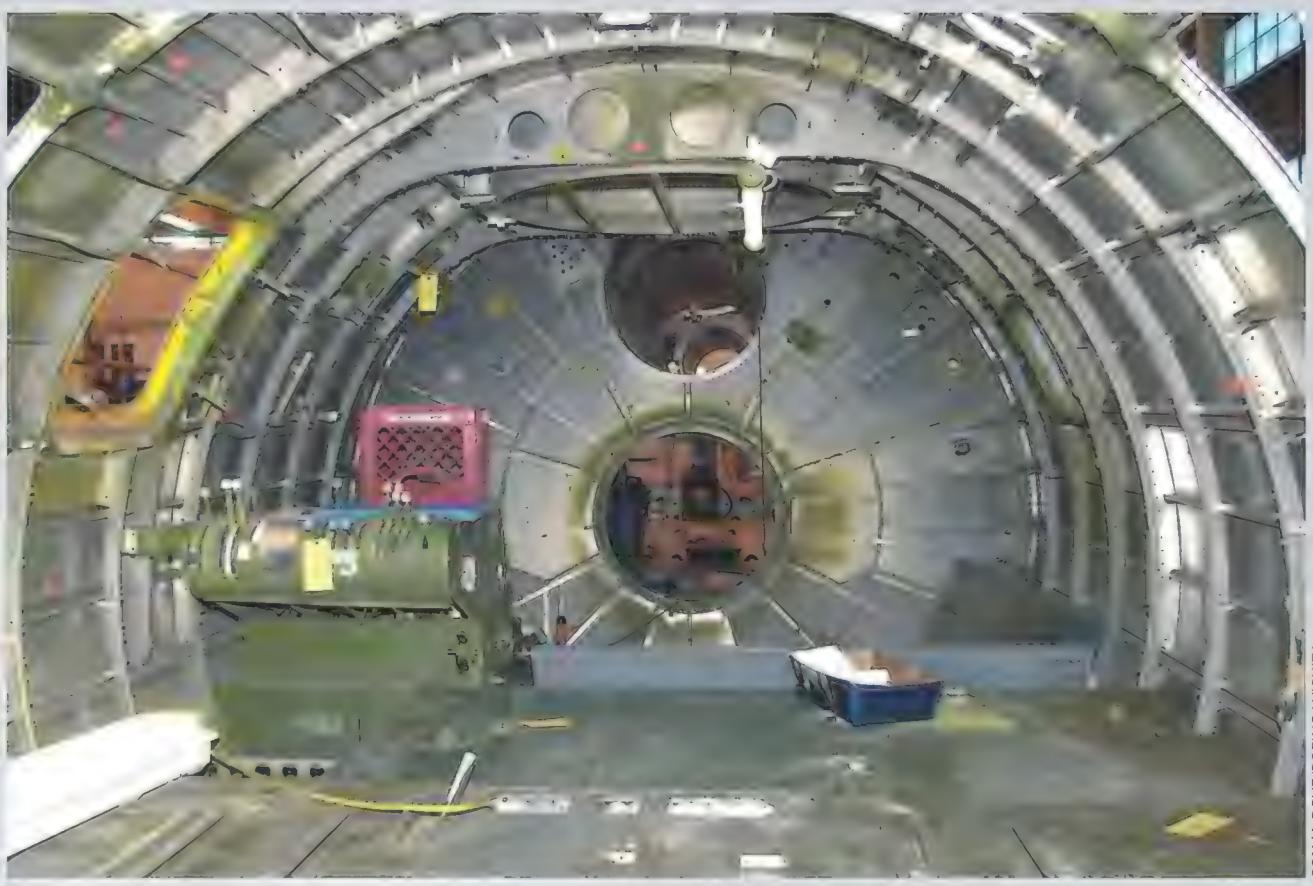
the seven dwarfs from the animated Disney movie *Snow White*; each of the airplanes in its squadron at Griffiss Air Force Base in Rome, New York, had had a different dwarf on its nose. Out of the entire squadron, which flew radar survey missions in the early 1950s along the east coast of the United States, *Doc* is apparently the only survivor.

The airplane was missing some parts,

Left: Volunteers Buck Tunnison Shirley Young, and Jesse Young (left to right) work daily on Doc. *Richard Almire helps to load a section of its tail, which is being swapped for a better one (above). On May 18, 2000, sections arrived at Boeing's Wichita plant (right) for a thorough cleaning.*

SONJA DOVE/BOEING WICHITA (3)

TIM DONNELLEY/BOEING WICHITA



SONJA DOVE/BOEING WICHITA

Jean Pauly, left, and Cliff Gaston, in 1940s garb, refit a window (left). Stripped, Doc*'s airframe (above) is like a new B-29's (opposite, top).*

but it was the Navy's airplane, and they drove a hard bargain. Needing a restored North American B-25 Mitchell for the National Museum of Naval Aviation in Pensacola, Florida, the Navy bureaucrats' proposition was simple: Deliver a restored B-25 and you've got your B-29.

Mazzolini learned of a B-25 in Venezuela, bought it, and had it shipped to the States to be restored by the Air Heritage Museum in Beaver Falls, Pennsylvania. Six years later the Mitchell was ready, and in March 1998 the swap with the Navy was completed. Mazzolini, now head of the United States Aviation Museum in Willowick, Ohio, which he had founded in 1992, first had the airplane towed 40 miles across the desert to an airport at Inyokern, California, so work could begin. Awful weather and a lack of equipment and workers dogged the project, so Mazzolini made what he describes as a "cold call" to the Boeing plant in Wichita, where *Doc* was built. Would Boeing help?

Jeff Turner, a vice president at the plant, approved the proposal, and in May 2000, *Doc* was disassembled, shipped to its birthplace, and ensconced in Boeing's experimental-flight hangar.

A volunteer force supervised by Boeing project director Dick Ziegler began the project with a thorough cleaning and polishing. Some of the helpers, like 83-year-old Charles "C.C." Briscoe, had built B-29s in Wichita during the war at this very plant. Despite 44 years in the desert, *Doc* is in pretty decent shape, except for some corrosion on the wings and landing gear. Because the airplane had never actually been used as a target on the firing range, only a single bullet hole was found.

The original asbestos-coated wiring will have to be replaced. And the vertical fin and rudder, which had been sawed off by the Navy either to clear some high-tension lines or to reduce the effect of desert winds (depending on whom you ask), will be replaced by one from the New England Aviation Museum in Windsor Locks, Connecticut. Tooling and jigs have been re-created in wood from original drawings, and missing parts have been fabricated from scratch. Ziegler coordinates closely with the Federal Aviation Administration to ensure that the airplane will get an airworthiness certificate upon completion.

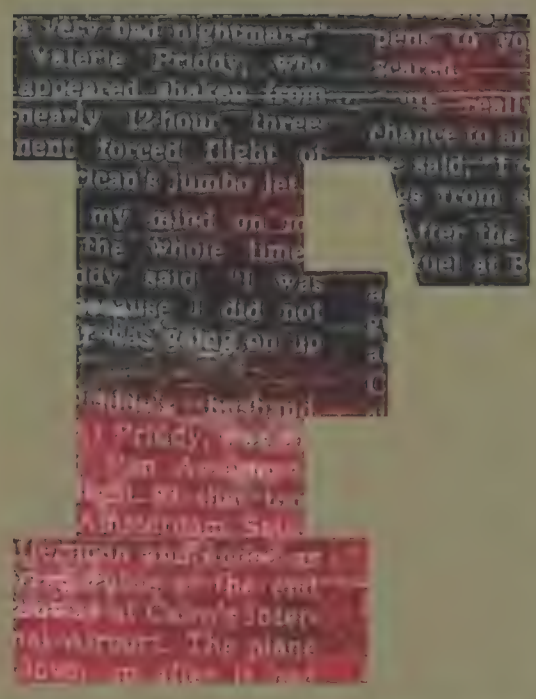
The crucial question, of course, is when will *Doc* fly? Ziegler steeples his hands, smiles, and says, "I'm an optimist, but we've got momentum. Local companies and donors everywhere have been most supportive. If we don't get any serious curve balls, I'd say end of 2002."

And will *Doc* go to Cleveland or remain in its birthplace? "Tough to say at this point," says Ziegler. "We've had an offer of a new hangar right here [in Wichita]. Right now it's up in the air." Mazzolini adds, "The people in the Kansas community would like it to stay there. I'd like to park it right out in my back yard, but I know that wherever it's based, I'll have to fly to it."

—J. Douglas Hinton

Armed and Anonymous

On your next flight, the passenger in the seat beside you could be a federal air marshal.



or Michael Mooney, the trip was a troublesome one. It had also been difficult on the other occasions he had traveled here. But here he was again, on an overcast November evening, having brought a small group of firefighter recruits from Atlantic City, New Jersey, to see for themselves what had occurred at this spot some two months ago. Mooney said he brought them here to contemplate what it meant to be a professional and do one's duty.

BY D.C. AGLE **PHOTOGRAPHS BY ERIC LONG**

"We attended the funeral of three New York firemen today," says Mooney, himself an Atlantic City fire captain. "We did it to show our support. And now we are here. I have been here [seven] other times since it happened. I have worked the site. I have come just as an observer, and I have brought other firemen who need to see this for themselves. As many times as I have come here, it still makes me sick to my stomach."

The devastation that occurred on September 11, 2001, at Church Street between Liberty and Vesey in lower Manhattan has more personal meaning for Mooney than for most. To him, the 16-acre site is not only the debris-filled tomb of so many civilians and his fellow firemen; it is also the symbol of a failure to protect the U.S. transportation industry. Mooney believes that he and others like him could have prevented the tragedy. He was once a federal air marshal.

"We were professionals and we knew our job," says Mooney. "I guess you could say we almost did our job too well. The hijackings stopped and the cutbacks came, and I was forced to leave. I guarantee you, if one air marshal had been on each one of those planes, this would not have happened. You don't bring a box cutter to a gun fight. And [the hijackers] would have been in one helluva gun fight."

There are some in the federal government who would agree with him. On September 19, the Federal Aviation Administration began accepting applications for a new generation of FAMs, or "civil aviation security specialists." To date, over 150,000 applications have been received for the $35,100- to $80,800-per-year job. An undisclosed number of applicants have been accepted and vetted for top-secret clearance, and an undisclosed number have been processed through the 14-week course. The FAA considers the number and identity of its marshals, the routes they fly, details about their training, and even the budget for the air marshal program to be matters of national security, and that's the way the FAMs like it. "We don't need people trying to dissect our infrastructure to figure out why they have an X percentage chance of meeting these guys on a flight," says Jack Donovan, one of the supervisors of the marshal program. "There is a new game out there that we are really trying to discourage. It's called 'Let's find the FAM on the airplane.' That's not a good thing because the flying public just needs to be reassured that we've got FAMs up there flying, and we're getting more and more everyday. And they should feel secure in that. So don't say 'Ah, she's one of them because she's got a bulge in her pocket.' That's not helping and chances are you would be wrong. Weapons concealment is part of the trade. People need to know that we have the tools to get the job done."

The tools and the people who will use them are tested and trained at the 5,000-acre William J. Hughes Technical Center, the FAA's research-and-development center near Atlantic City, New Jersey. Behind the chain-link fences and barbed wire, bright lights and security cameras, instructors are busy getting the next generation of air marshals airborne.

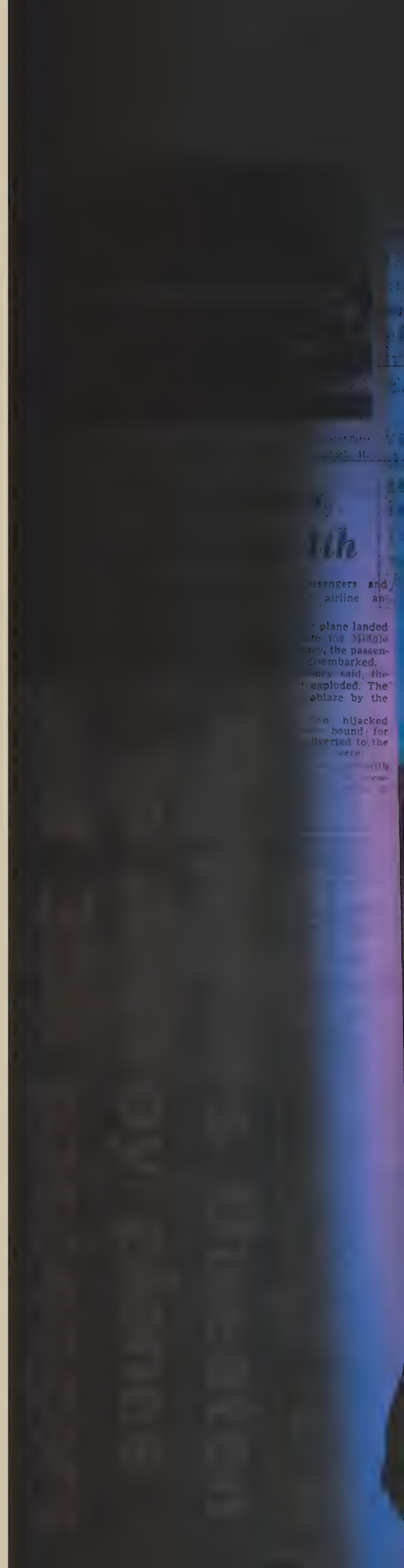
Training includes everything from stress management and international law to cross-cultural communications and medical procedures. Add to the mix, as Michael Mooney found out three decades ago, lots and lots of weaponry skills: drawing weapons, reloading, firing with one hand, switching hands, changing targets, firing from a seated position, firing while moving, and reloading while moving. Training facilities include three outdoor ranges with moving targets, an indoor training room with interactive computer graphics, and a close-quarters countermeasures/personal defense training room with protective equipment and dummies. It's no wonder, then, that air marshals have the best fire-range qualifications of all federal law enforcement employees.

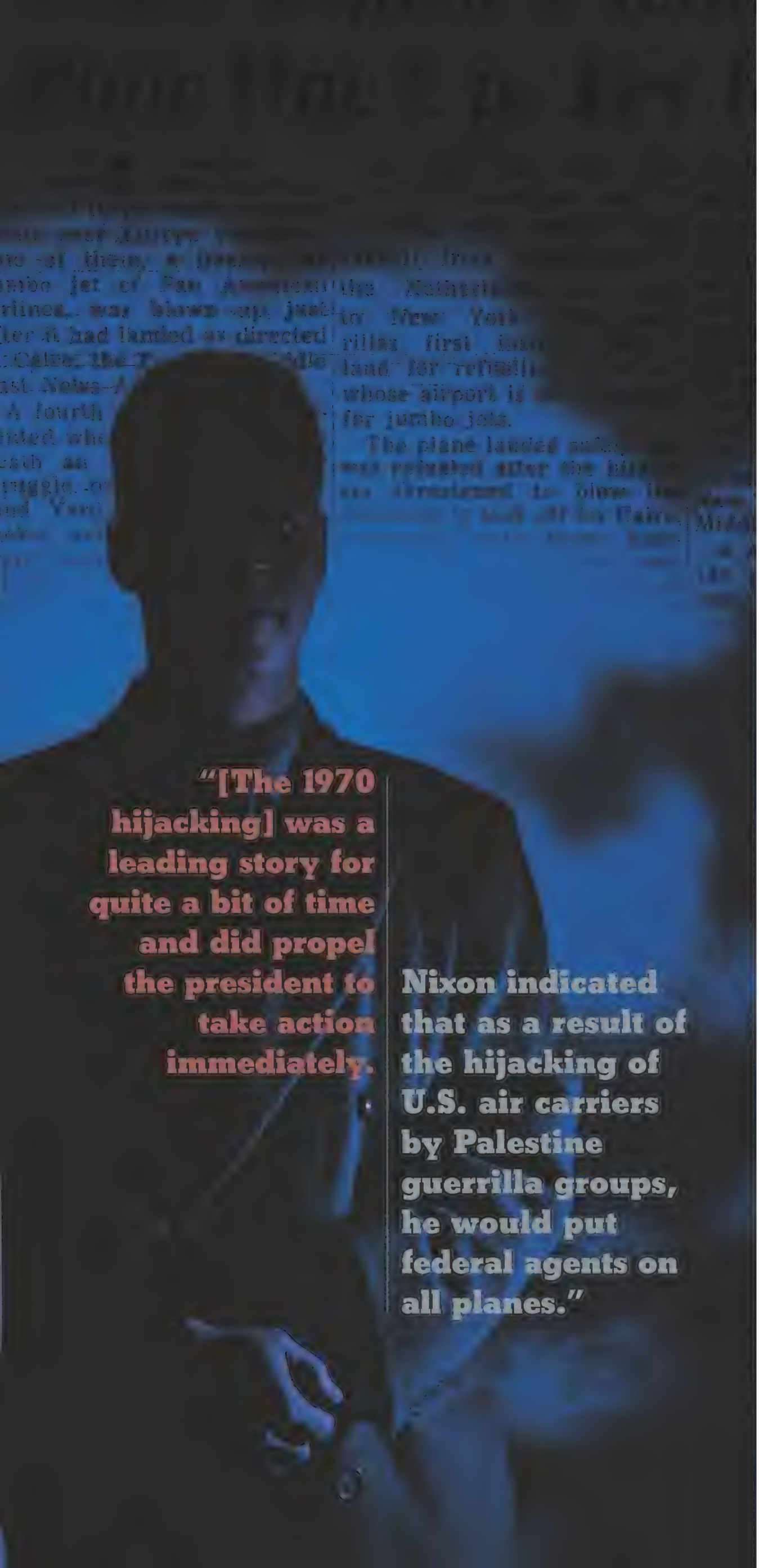
The program also uses an inactive five-story air traffic control tower, a state-of-the-art fitness facility, and an operations center capable of secure communications worldwide. Mock missions are flown in a retired Boeing narrow-body 727 and a Lockheed wide-body L-1011: There, FAMs mix it up with "terrorists," practicing their moves and techniques with paintball rounds. For firing the real thing, the FAMs have a 360-degree, live-fire shoothouse, which can be configured as either a narrow-body or a wide-body aircraft complete with computer-controlled targets and a bulletproof observation platform.

"We'll pick a scenario based on something that's happened in a hijacking somewhere around the world in years past," says Donovan. "And we'll take them through it and everything's on video so that you can provide immediate training feedback. We'll ask what they think occurred. They answer. Then we play the tape back and show them what really happened and what they missed. It is invaluable training."

There are more past incidents for trainers to use as scenarios than most people realize. The first recorded instance of the hijack of a civilian carrier occurred on February 21, 1931, after a young Pan American Grace Airways pilot named Byron 'By' Rickards took off from Lima, Peru, with three passengers and a load of mail in a Fairchild FC-2 monoplane (the aircraft now belongs to the National Air and Space Museum). Upon landing in Arequipa, Peru, Rickards was confronted by gun-waving revolutionaries intent on commandeering the single-engine Fairchild for a drop of propaganda leaflets on local villages.

" 'By' told me this story 60 years ago," says William Krusen, a former Panagra pilot and author of the book *Fly-*





ing the Andes: The Story of Pan American Grace Airways and Commercial Aviation in South America, 1926–1967. "He said he thought one of his passengers was in on it. But he didn't try to fight any of them off or anything like that."

Rickards steadfastly refused to fly the revolutionaries anywhere, and the standoff continued for 10 days. Then, on March 2, the would-be hijackers abruptly informed Rickards that even without their leaflet drop, the revolution had succeeded and their comrades had the capital Lima under firm control. So Rickards began to barter, and soon it was agreed: Rickards would be freed if he gave one of the revolutionaries a lift to Lima. The world's first hijacking had ended in a draw.

In perhaps one of the most remarkable coincidences in aviation history, three decades, five months, and seven days after his first run-in with armed revolutionaries, By Rickards was again involved in a hijacking attempt. "He was a captain at Continental by then," says Krusen. "Two hijackers wanted to fly to Cuba and it turned out to be in By's plane."

On August 3, 1961, Rickards was in the left seat of a Continental Airlines 707 on a flight out of El Paso, Texas, when ex-convict Leon Bearden and his teenage son, Cody, took over the airliner while it was still on the ground. The two amateurs, with very little preparation and what has been described as even less intellect, thought they could commandeer an airliner and proffer it to Fidel Castro as a gift, but these kin-in-crime never got off the ground. Security officers in four cars chased the Boeing down the runway and shot out its tires. After a two-hour standoff, the duo was captured.

Although perceived by some as a somewhat comedic episode, the case of "the gang that couldn't hijack straight" signalled a change in the motivations of hijackers. Since World War II, nearly all acts of hijacking had involved individuals attempting to escape from repressive governments, like those of the Soviet Union, Czechoslovakia, and East Germany. But in 1961 the rules changed. The attempt on Rickards' Continental flight and the successful hijacking of National Airlines and East-

Ping Ping Ping

Federal air marshals carry the polymer-framed .357-magnum Sig Pro SP2340, firing bullets that are frangible—on impact with metal or glass, they mushroom and break apart, so they can't rip into an airliner's fuselage. FAMs have been instructed that when the aircraft is at risk and they have to fire their Sig Pros, they must shoot to kill. "These guys don't pull their weapons out and start spraying," says Bo Bosiljevac, a former Army Ranger, Navy SEAL, and currently a special operations and counter-terrorism instructor at Blackwater Lodge, a privately owned, 5,200-acre firearms and tactics training facility in Moyock, North Carolina. "They don't rattle easily, and when they pull their weapons out, they take deadly aim. They've trained repeatedly and they do not miss.

"I cannot tell you exactly how air marshals do things," says Bosiljevac. "But I can tell you some standard practices that are used by those in the security field." He sits down in one of the chairs at a Blackwater firing range. "Now if something happens and I need to act, I do not have to stand up to do so," he says. "I can use the seat in front of me as a gun rest, take the hand the gun is not in and place it against [the head of] the passenger in front of me so they do not get in the line of fire. I can even use the elbow of my gun hand to keep the other person in front of me out of the way. Drawing your weapon is one quick, fluid movement. You would be surprised how fast a trained agent could draw, accurately aim, and get a shot off—faster than most people could pull the trigger." In what seems like one motion, Bosiljevac draws a holstered semi-automatic pistol and fires three quick shots: *ping ping ping*. Three times he hits a metal target 20 yards away. Then Bosiljevac gets up and moves forward, constantly firing, constantly hitting the target. "Surprise, speed, and aggressive action are the cornerstones," he says. "When you engage, aggressively identify yourself as a counter-attacker—that draws the terrorists' entire attention onto you. They cannot help it. It is an automatic reflex—self-preservation. That pulls the terrorists' potential deadly force away from the cockpit, flight crew, and everybody else and aims that lethal force on you." And studies have shown that in a one-on-one gun battle between a trained terrorist and a trained agent, the agent is going to win. "I know some FAMs; all I can tell you is that they are extremely sharp, highly motivated guys," Bosiljevac continues. "I would not want to tangle with any of them on any given day. And that is no joke. They are really, really good."

ern Air Lines flights to Cuba earlier that year had brought piracy to the airways of America.

The U.S. government responded to the new threat by passing a law making hijacking a crime punishable by imprisonment a minimum of 20 years or death. And in 1962, President Kennedy started the federal sky marshal program. The FAA deputized 20 of its employees as U.S. marshals and utilized them on flights that agency analysts determined to be high-risk (the FAA will not identify these flights). The Kennedy administration kept the program secret. But with only 20 sky marshals in a secret program, the number of hijackings of U.S. aircraft continued to rise dramatically. In 1968, 22 hijackings to Cuba were attempted, and 18 succeeded. In 1969, there were 40 attempted hijackings of U.S. airliners. And while those numbers were alarming, it took the events of September 6, 1970—what came to be called "hijack Sunday"—to set in motion the story of armed policemen in the sky.

On that day four airliners were hijacked by gun- and grenade-toting zealots of the Popular Front for the Liberation of Palestine. Two of the airplanes, a TWA 707 that had taken off from Frankfurt and a Swissair DC-8 on a Zurich-to-New York trip, were flown to Dawson's Field, a former Royal Air Force airstrip in the middle of the Jordanian desert. A third airliner, a Pan Am 747 that had departed Amsterdam, was hijacked to Cairo because it was too large to land on the Dawson's Field runway. The following day the almost new 747 was destroyed by suitcase bombs. On September 13, the two airliners held hostage at Dawson's Field were blown up alongside a BOAC VC-10 that had been hijacked to Dawson's four days earlier on a flight from Bahrain to London. Remarkably, the passengers and crew from all three aircraft survived by getting out before the bombs were detonated.

In the fourth hijacking attempted that Sunday, two armed PFLP terrorists attempted to take control of an Israeli El Al 707 flying out of Tel Aviv. After a running gun battle between the terrorists and several El Al sky marshals, the flight was diverted to London's Heathrow Airport, where it dropped off the two hijackers, one restrained, the other dead.

The hijackings were front-page news around the globe. "There was no question it was a leading story for quite a bit of time and did propel the president to take action immediately," says Martin Pollner, a former director of law enforcement for the U.S. Department of the Treasury and one of the fathers of the 1970 sky marshal program. "Nixon indicated that as a result of the hijacking of U.S. air carriers by Palestine guerrilla groups, he would put federal agents on all planes."

Nixon put the U.S. Customs Service in charge of the fledgling sky marshal program, and the agency hired 1,500 marshals for use on both domestic and international flights. Although much of the program was secret, its existence was made known and the marshals were given one widely publicized mandate: Shoot to kill. One of those who would eventually carry the license to do just that was a young Vietnam vet named Michael Mooney. "They were taking United States flagships over to North Africa and blowing them up," says Mooney. "I was really pissed off that these people were hijacking and assaulting Americans."

Mooney had served in the U.S. Air Force; he had qualified as a sharp-

shooter and pulled duty as a guard for military convoys. After leaving the service in 1968, he attended college until a newspaper ad caught his attention. "They were looking for police officers or service veterans who were combat-trained and ready to do what needed to be done," he recalls. "You knew that you were doing a good thing for your country. And it was my idea that no one was ever going to hijack my plane and put it down in the desert and set it on fire—period."

The same ad caught the eye of Bill Ruzzamenti, a college-weary 22-year-old who had just gone through U.S. Army National Guard basic training and was looking for something interesting to do. "I was going to law school at the time," says Ruzzamenti, today a drug task force consultant for the Drug Enforcement Administration. "I had just gotten married and was burnt out on the whole academic thing and basically decided I needed a change."

Mooney's and Ruzzamenti's applications were two of the thousands received; the Customs Service used an extensive written test to thin the ranks. Mooney was the only one in his class of 360 applicants to make it; Ruzzamenti was selected from 500. They then underwent a series of interviews and psychological and physiological tests.

"In those days, our training was in Fort Belvoir, Virginia," recalls Mooney. "All day long, 10 hours a day, classroom and testing. We were trained in special weapons tactics, bombs—we were trained how to deal with one at 30,000 feet—and drugs. You name it, we trained for it. There was intensive firearms training. Probably shot every day for seven weeks. And if you failed any one portion of any of the testing criteria, you were immediately phased out."

Mooney recalls an instructor the students called "the Hook," who would knock on the doors of dropped candidates at night and tell them to gather their things. The next morning there would be vacant seats at the breakfast table.

In Ruzzamenti's class, the customs agents didn't even wait for nightfall. "It was kind of weird: Sometimes you would be in a class or at the range and they would just call a guy over and he'd never come back," says Ruzzamenti. "There were whispers that something came up on his background or that he'd flunked a test, but all we really knew was that he was gone and we never knew why."

Both Mooney and Ruzzamenti were assigned to Pan American, mostly flying from New York to Europe and the Middle East. "On a typical mission you'd be on duty two hours before a flight to meet with the pilots and flight crew," says Mooney. "We were in civilian clothes and undercover and they needed to know and be comfortable with who we were."

"We actually had a class to help us develop our little b.s. stories to tell people. Guys would come up with ones that they were junior executive with so and so. Some of the old ex-military guys came up with these off-the-wall stories. They had inherited all these weird fortunes or they were relatives of J. Paul Getty and on and on. You can imagine them in first class while wearing a polyester suit! It was pretty funny."

Remarkably, "the biggest problems I ever had were with the plane captains," Ruzzamenti says. "Often times the pilots would tell me 'I don't care who you are, you are not to pull your gun out, and if we are hijacked we will just go to Cuba.' I cannot tell you how many times I had that said to me. It was a very common expression. A couple of times I even had captains of aircraft say that they wanted the guns—that they would keep them up in the cockpit of the aircraft, and that if I needed it I could come up and get it, which is just a ludicrous idea. They would say stuff like that and you would have to get into a whole conversation."

After the "get to know the guys with the guns" session was over, the sky marshals (according to one former FAM, air marshals almost always work in teams of two or more) would slip into the airport terminal and mingle with the crowd. "There were two reasons for this," says Ruzzamenti. "First, we wanted to blend in with the rest of the passengers. Secondly, we wanted to see if there was anything suspicious or unusual going on. If people were clandestinely meeting behind posts or talking to each other but really not flying together or if they are exceptionally nervous, we could identify them before the flight as potential threats."

Once a federal air marshal takes his seat (he sits on the aisle to have better mobility and sight lines), he is prepared to take action against not only would-be hijackers but also overly curious and garrulous travelers. "Your job wasn't to converse with the passengers," says Mooney. "It was to stay alert, undercover, and ready to react. You were all about business. During training they taught us how to create a good cover story."

"We actually had a class to help us develop our little b.s. stories to tell people," says Ruzzamenti. "Guys would come up with ones that they were junior executive with so and so." Air marshals

shals stationed near the cockpit found themselves sitting in first class and adjusted their cover stories accordingly. "Some of the old ex-military guys came up with these off-the-wall stories," remembers Ruzzamenti. "They had inherited all these weird fortunes or they were relatives of J. Paul Getty and on and on. You can imagine them explaining this to someone in first class while wearing a polyester suit! It was pretty funny."

Ruzzamenti's story was that he was traveling first class because his father was an airline pilot and they were meeting up to do some sightseeing. Mooney came up with one that was easy to believe but not likely to lead to further conversation. "I was a school administrator attending a conference," says Mooney. "It seemed to work real well. Not too many people were really that interested in my job."

Mooney and Ruzzamenti remain as secretive about the air marshal methodology of the 1970s as the current federal air marshals are of the techniques used today. "I imagine not a hell of a lot has changed in the last thirty years," says Mooney. "You are still dealing with a steel tube 30,000 feet in the air." He will say he found a need to keep well hydrated. He ate very little and tried not to get too comfortable lest he doze off—a definite no-no in the air marshal world but hard to avoid when you are flying through multiple time zones on 10-hour international flights. "I drank a lot of coffee," says Mooney. "It was tough. You have to be alert and ready to go for the entire 10 hours."

Something else Mooney will allude to with a subtle, somewhat crooked smile: the layovers on those international flights. "I was a single guy," he says. "The 747 was staffed by 16 stewardesses. And the stewardesses at that time on overseas flights tended to be the younger, more beautiful ones. And they knew who we were. And when we would get to Paris, we would find our own way to our hotel, but we'd stay at the same hotel as the flight crew. You can imagine being in a foreign country. You don't know Paris. And stewardesses like to show you all around town."

Three years later, with the number

of hijackings in decline, Nixon's sky marshal program was scrapped and replaced by a smaller number of marshals overseen by the FAA. Seeing the writing on the cabin wall, Mooney left the program and went to work as an Atlantic City fireman. He could only look on when in 1985 two Lebanese Shiite Muslims, hoping to negotiate the release of Shiite prisoners in Israel, hijacked TWA Flight 847.

That flight had departed Athens when it was hijacked and diverted to Beirut, where additional hijackers climbed aboard. A two-week ordeal ended in the death of one passenger, U.S. Navy diver Robert Stethem. As a result, President Reagan ordered the expansion of the ranks of armed sky marshals, who were renamed "federal air marshals." Again the program grew in size and scope, but only a few years later it shrank again as the hijacking threat diminished.

While the federal air marshal program continued to soldier on, it was revealed by U.S. Department of Transportation Secretary Norman Mineta at a security conference last October that only 32 active-duty air marshals were working prior to September 11, 2001. Now, of course, the ranks are growing again.

Those who survive the three-and-a-half months of intensive instruction must be able to travel regularly for several weeks at a time, work irregular hours, and be on call 24 hours a day. While deployed, they have limited contact with family and limited time off. Also, according to the FAA's air marshal job announcement, FAMs are expected to spend some of their non-flying hours in "foreign countries that are sometimes politically or economically unstable and may pose a high probability of terrorist or criminal activity against the U.S. Government. In addition, some locations may present health hazards such as poor sanitation and unsafe water."

Another sacrifice the new batch of marshals may endure is career insecurity. Aviation security expert Charles Slepian sees parallels between the present situation and that of the mid-1970s and late '80s, when the threat of hijackings had receded and many of the government's highly trained sky and air marshals were looking for work. Says Slepian: "I have a son-in-law who is a federal agent in Florida. He was being heavily solicited to transfer to the air marshal program. I said if he did, he would be unemployed within a year. I think technologically we're going to make it impossible to get into the cockpit and take over the aircraft. So we're not going to have the same situation as we did on September 11. Which raises the question what the air marshals' function is going to be."

"We'll take them through it and everything's on video so that you can provide immediate training feedback. We'll ask what they think occurred. They answer. Then we play the tape back and show them what really happened and what they missed. It is invaluable training."

In the meantime, it is wise to heed the admonitions of flight attendants and carefully follow the new security procedures of air travel. On November 12, 2001, a US Airways passenger did not follow the new federal rule stating that in the last half-hour of an approach into Reagan National Airport in Washington, D.C, all passengers must remain seated. About 15 minutes before the Airbus A319 was to land, Raho Ortiz, without a word to anybody, got out of his seat and walked briskly toward the front of the aircraft. As Ortiz neared the cockpit, a federal air marshal seated near the front of the airplane made himself evident and yelled "Stop!" Another air marshal appeared from the back of the airplane with gun drawn. After Ortiz was handcuffed, the marshals ordered the other 106 passengers to put their hands behind their heads and later rest them on the seat backs in front of them. The airliner, per new FAA procedures regarding such incidents, was diverted to Dulles airport in northern Virginia (directing it away from potential targets such as the U.S. Capitol and the White House). As he lay face down on the floor, Ortiz, a lawyer for the Environmental Protection Agency, could be heard saying "I'm sorry. I just wanted to go to the bathroom."

"You cannot take anything or anyone for granted," says former marshal Mooney. "In my day I had all the confidence in the world. I knew, if I had to, I could nail a terrorist between the ears if he was standing at one end of a 747 and I was standing on the other. And that was before all the new firearms technology and simulator training. This new group, these new air marshals, are going to be something."

Mooney and his crew of Atlantic City firemen watch from a special platform, erected for VIPs and the families of those lost at the World Trade Center. On the unfinished wood railing in front of them, scrawled in ballpoint, are the plaintive entreaties of family members of the dead and missing. In the distance, the firemen watch as one of the constantly moving cranes excavates another layer of debris and unearths a new chamber of smoldering heat. Exposed to the air for the first time in two months, the chamber ignites and the ever-present trickle of smoke that continuously rises from the ruins suddenly transforms to a surge of smoke and flame. As the Atlantic City firemen look on, several N.Y.F.D. firemen turn a half-dozen hoses loose on the source, and in time the billowing plumes begin to dissipate.

Soon, Mooney and his group of firemen take their leave of ground zero. Those still at the site hear the unmistakable roar of a heavy jet climbing out of Newark. No one can help glancing skyward.

BA

One of life's humbling moments comes for the fighter pilot racking the simulator around at 30,000 feet with the bad guys closing in. Even though he has a thousand dogfighting flight hours and is attached to the ground like a slab of granite, he feels airsick. Why does it hit him in the simulator but not in his airplane?

Every time he takes to the sky, the pilot takes in hundreds of physical cues, some very subtle, that help orient him within the cockpit. Even the best simulators can't reproduce something as seemingly inconsequential as the odor of hydraulic fluid. For a veteran military pilot, such omissions might cause disorientation, which in turn can bring on waves of nausea, sweats, irregular breathing, vision disturbances, and other symptoms of motion sickness.

Ron Kruk, a motion sickness expert for CAE, a Canadian company that manufactures simulators, says, "A simulator can't replicate the real world completely, like giving the acceleration of a real aircraft. Parts of one's nervous system are fooled by that and other parts are not. So you get sensory mismatches. Simulator sickness is a special case of motion sickness. Maneuvers that get you sick in a simulator might not get you sick in the aircraft." Scientists don't fully understand why a pilot can feel fine in a simulator one day but turn green the next, but they do know that disorientation often originates in the inner ear, where tiny hairs, or otoliths, can indicate you're stationary when your eyes say you're not. So even though the pilot feels his feet on the floor and his inner ear says everything is straight and level, the simulator's electronic scene tells his eyeballs that he's in a steep bank or, worse, a roll.

To get reoriented, a pilot might have to step back for a moment and sit qui-

BY WILLIAM GREGORY

RFOLOgy

What scientists haven't solved and hot-shot pilots won't talk about

Opposite: Real deal or simulator? A pilot's body can't always tell, which can set his head spinning. Helmets, like the Gemin-Eye (above), trigger motion sickness even more often.

etly. But, as Captain Angus Rupert, a flight surgeon at the Naval Aviation Aeromedical Research Laboratory in Pensacola, Florida, points out, "These are people who do not tend to say 'Hey, I have a minor problem here.' They don't even say anything when they have a major problem."

The military itself is unwilling to say it has a "problem" with motion sickness. The official response from Colonel James Little, who directs the motion sickness training program for the Air Force: They weed out the most sensitive recruits early on so it rarely becomes an issue. But the military and NASA currently fund the bulk of motion sickness studies, including investigations into simulator sickness, so they're obviously looking for answers.

People like Kruk contend that airline and military transport simulators have reached a stage of fidelity that eases adaptation. But even the less susceptible pilots can face discomforting electronic aberrations, like jitter, which is analogous to the flickering of a TV screen. More disconcerting is latency, in which too many milliseconds pass between the time the pilot moves the stick or ailerons and the time the scene responds. Another problem is off-axis viewing, in which the student flying is fine and the instructor to the side is uncomfortable. High fidelity or not, simulator software and hardware have to be in tune.

Dennis McBride, a physician and former executive director of the Institute of Simulation and Training in Orlando, Florida, believes that superhigh fidelity in the newest simulators actually causes the trouble. The higher the fidelity, the more likely experienced pilots in particular will run into problems. No simulator can offer a perfect reproduction of all the forces at work in a modern jet in flight.

McBride recalls one dilemma the Navy faced with the A-12 stealth attack airplane before the program was canceled. Its concept of operations, he says, called for intense shipboard simulator rehearsal just before a mission. Since adaptation to minute changes in cues is a factor in motion sickness, McBride says, a pilot could adjust to the simulator and then get disoriented in the real airplane, where his performance could deteriorate.

Exactly how much the disconnect between a simulator run and a real flight can affect performance is unclear. Several researchers believe not enough work is being done on this crucial issue. While no one could cite an instance of a pilot crashing a jet or even getting in a car accident after an extended stay in the simulator seat, there's plenty of evidence to suggest such a mishap is possible.

William Ercoline is a former instructor pilot who has taught in heavy, motion-based simulators and now works on spatial disorientation countermeasures at Brooks Air Force Base in Texas. He says that once a pilot becomes stressed, "he is more likely to experience what we call Type One disorientation, which is unrecognized. That means he or she will start focusing on one thing and let another go, and it could be the attitude of the airplane. I've seen that. I have some friends that do aerobatics and they get this thing called the wobblies, which causes long-term effects. They start driving their cars, start shaking, and have to stop."

Kay Stanney, an industrial engineer at the University of Central Florida, tells of a helicopter pilot who, driving home after a long hop in the simulator, suddenly "saw" his car roll upside down. Though he got the car off the road and his head right side up, the experience has become a legend in the small world of simulator sickness research. Robert S. Kennedy, a Navy flight surgeon and expert on motion sickness, tells a similar story about an operator of a Navy Landing Craft Air-Cushion vehicle (LCAC): After getting out of a simulator, he began weaving so much on his drive home that cops

pulled him over for drunk driving. The man was having a post-simulator disorientation flashback.

Disorientation can happen in flight because of the same man-versus-machine disconnect. A high-time Navy pilot, who asked not to be identified, remembers a night bombing drill in an A-7 in which he could see the lights of the target ship through the windscreen, paired with its FLIR (forward-looking infrared) head-up display image. Abruptly the FLIR ran out of gimbal travel and the two scenes diverged. "I had an overpowering wave of nausea," he recalls, "but I had enough instinct to pull back hard on the stick."

At Fort Rucker a pilot takes the controls of an AH64 Apache simulator.

The Federal Aviation Administration and the military have established limits on the amount of jitter and latency that can take place in a simulator, but no standards exist for helmets. In one study Stanney and Kennedy found that about 10 percent of simulator users reported vision-related symptoms, like a headache, another 7.5 percent reported nausea, and five percent suffered from disorientation. While using a virtual reality helmet, a remarkable 25 percent experienced nausea, and another 30 percent reported disorientation.

A full-motion simulator can cost $10 million to $15 million, while a helmet costs maybe $50,000, which helps explain why the military still uses them, even though they are more likely to cause motion sickness. Indeed, military instructors are incorporating more helmet displays into flight simulators; well engineered, these can work just fine, says Kruk.

Helmet displays are important for reconfigurable helicopter simulators, like the one in an Army program that can be changed from a UH-64 Apache to a UH-60 Black Hawk by switching moveable cockpit modules around and exchanging virtual reality software. Engineers still have to make sure the tracker beacon in the headset stays in sync with the scene that rolls by on the screen.

Researchers like Kennedy are looking into the causes of all of these reactions and hoping to find a way to counteract some of the more dangerous side effects. In his office, Kennedy has a seven-foot-wide, six-feet-high drum made from aluminum stringers, which he uses to conduct tests on motion and peripheral vision. He's wrapped a corrugated-cardboard skin around it and pasted some cheap wallpaper with a nauseating horizontal ocean wave pattern on the inside. The test subject sits in a chair two feet off the floor with nothing much visible except the wallpaper.

"Close your eyes," a Kennedy aide says to a young man in a demonstration run, whereupon the drum gradually spins. When the speed tops 130 degrees a second, the aide gives an "eyes open" command. All the subject sees is a fast-moving ocean scene turning right. But as the drum accelerates toward its maximum, 160 degrees a second, the ocean scene seems to stop and the chair appears to spin left.

No question, it's quick and queasy, a classic case of the inner ear saying "You're not moving" and the eyeball saying "Oh yes you are."

David Graeber is writing a doctoral dissertation on the reactions of volunteers spinning in Kennedy's drum. His findings reiterate what pilots and sailors learn on the job: Adaptation is the key. When you're in a simulator, don't try to bull your way through motion sickness, something hot-rock pilots, disdainful of electronic flying, are prone to do. Back off, get acclimated in short bursts.

Pilots tackle antisubmarine warfare scenarios inside the Merlin Simulator's bubble.

Neal Finkelstein, an Army computer engineer, is dealing with the "tough guy" problem among infantry who use virtual reality helmets for battlefield simulations. Even though they have their feet planted firmly on the ground both in the chair and on the screen, "one in five is the drop-out rate," he says, "and we're still trying to figure out why so many people are getting sick. These big Army guys get in there and say 'I'm really tough.' But the more they fight it… They've got to back away.

"Helmets are tougher than screens. No other reference point is visible in a helmet, just that claustrophobic type of environment. Moving the head is not something people think about; they just automatically move it."

Kelly Kingdon, a Canadian studying cyber-motion under Kay Stanney, shows off the test rig, one that comes closer to Kennedy's wallpaper drum than what pilots meet in a simulator. A computer program generates a maze of three long corridors and 29 rooms onto a display in a Virtual Research B6 helmet, which has micro-optics that produce realistic immersion in a scene flowing by, comparable in quality to graphics on a home computer.

A single trip through the maze, self-driven with a standard computer mouse,

takes 15 minutes and includes a set of mouse-actuated tasks. As you move through the corridors, various "jobs" pop up: Find the door to the hall in a room with psychedelic-colored walls; put three shapes—a star, a cylinder, and a circle—into slots. Throughout the test you have to keep "moving" down the hallways as synthetic scenery slowly flows by. If you move too slowly the scene goes into a roll. Though not as overpowering as being in Kennedy's drum, the experience can be unsettling if the test goes on long enough.

Stanney's students have put over 1,000 student volunteers through the test. Unlike pilots who go through screening, 90 to 95 percent of the students reported at least one symptom, like a headache, but only 1.5 percent got violently sick. Rupert says that in rare cases such symptoms can last for a month or two.

All of these tests have provided some basic answers, with more subtle solutions perhaps to come. Improving the technology for the virtual reality helmets will help. So will getting tough guys to back off and, just as important, hard-driving instructors to lay off.

When an instructor flash-freezes the simulator at 500 knots (575 mph) to start a new dogfight and cram in more combat per hop, he makes the student feel as though he's smacked into a mountain. When a pilot's cold grounds him, the first thing the operations officer does is send him to catch up on his simulator syllabus. Feeling below par, maybe with ear complications, the pilot is all set up for simulator sickness. None of these problems might be life-threatening, but what if the same pilot winds up in a regular cockpit the next day still feeling sub-par and slightly disoriented, because of subtle discrepancies between the simulator and his cockpit?

Researchers like Kennedy are trying to come up with basic guidelines to prevent such problems, including making sure pilots take shorter runs in the simulators. Both the Air Force and the Navy have tried adaptation drills. The Naval Aviation Aeromedical Research Laboratory in Pensacola, Florida, has a 20-foot rotating room called the Coriolis Acceleration Platform, in which people have lived as long as six weeks. The room constantly changes the rules of orientation. "It rotates very slowly," Rupert says, "three revolutions per minute, one every 20 seconds.

"It's like flying a single-engine piston aircraft," he continues. "When you push the nose over, it tends to yaw to the left, because that blade in front of you is rotating clockwise. The same thing happens in the inner ear, in those little canals, in the rotating room."

Because of its career-limiting implications, active-duty pilots hate talking about simulator sickness, but the longer they try to tough it out in a simulator run gone bad, the more severe their symptoms will get. Maybe they can console themselves with the knowledge that when it comes to enduring the virtual reality chair or helmet, sometimes it's the most adept pilots who have the hardest time.

ASTRONAUTS TURN GREEN TOO

The Congressmen wanted to know if John Glenn had gotten nauseous while journeying in space. His Russian counterpart, Gherman Titov, had gotten very sick on his 1961 Vostok 2 flight, but Glenn insisted, "Oh no, of course not." Later the American let slip, "It's not so bad once you get used to it." Well, if there's no problem, what is there to get used to, asks flight surgeon and motion sickness researcher Captain Angus Rupert, after telling the tale.

After decades of putting up a macho front, U.S. astronauts are finally fessing up to their struggles with motion sickness. In a recent report on space physiology, Deborah Harm of the Johnson Space Center in Houston, Texas, found that U.S. astronauts reported no symptoms with Mercury and Gemini, but the number of crew members reporting symptoms rose to 35 percent for the Apollo program and 60 percent for Skylab. Currently, Harm and her co-workers write, "it is estimated that 80 to 90 percent of all shuttle crew members experience some symptoms of motion sickness."

Harm says astronauts still don't talk much about "flashbacks" and spaceflight illusions. Sometimes in space they wake up and can't sense where their legs and arms are. One Russian cosmonaut went to sleep on the Mir space station with his arms folded and when he woke, he was certain that they were still crossed; in fact, they were raised straight up.

Sometimes illusions persist after landing. One astronaut reported that on his first night back on Earth, he had the sensation of rolling over in bed, so he grabbed the edge of the bed to keep from "falling" onto the floor. All the time he was lying flat on his back. Some astronauts report that while climbing stairs, they feel the stairs are coming toward their feet, rather than vice versa.

"Astronauts are missing the key most important piece of information: where is down," says Rupert. "On the ground," he adds, "left and right, up and down have meaning. But not in space. People get disoriented very quickly."

When astronauts lose their reference point in space, they instinctively choose to align with either the visual scene around them or their bodies' vertical axis. The former group have symptoms that are more severe and last much longer in spaceflight than the latter, says Harm.

The Johnson center has two simulators that help prep astronauts for situations in which the inner ear may feel a tilt but the eyes see everything as linear. And when the eye and ear don't agree, motion sickness can kick in, even among the most experienced astronauts.

Shooting the Moon

How a clever camera and its irascible inventor captured the lunar surface—but not the hearts of Apollo astronauts.

by Joseph Bourque

The Apollo Lunar Surface Close-Up Camera has to be the ultimate point-and-shoot. It cost $1.3 million—and that was 30 years ago. Designed to shoot close-up stereo pictures of the moon's surface, it was also called the Gold camera, not because it was pricey but because the man who thought it up is Thomas "Tommy" Gold, a British scientist who fiddled in his basement with a 35-mm Nikon and a wooden template until he had the proper angles, focal length, and other requirements for the moon camera's optics. ("I took a beautiful picture of a grasshopper—it was absolutely gripping," Gold recalls.) Kodak provided the technology and built the camera, known officially as the ALSCC; it was used on the moon by Neil Armstrong, Alan Bean, and Alan Shepard during Apollo 11, 12, and 14.

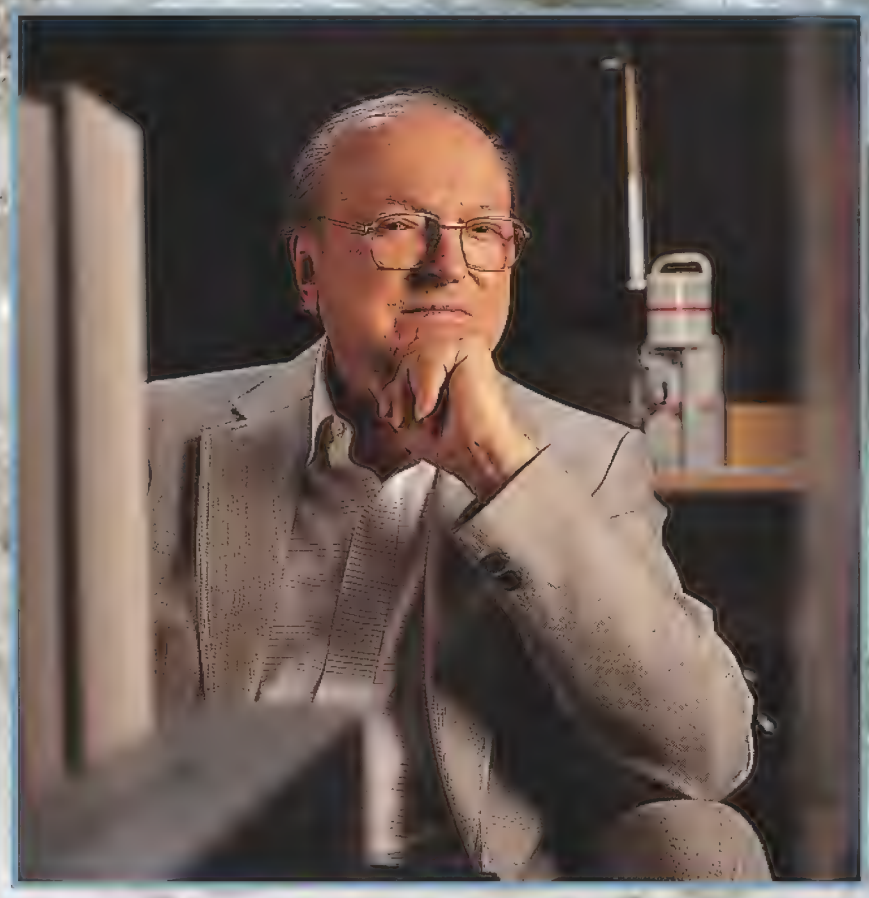
The slide pairs produced by the Gold camera, seen with a stereo viewer, show stunning 3-D glimpses of the lunar surface in segments measuring seven by eight centimeters (2.8 by 3.2 inches). They show what you would see if you could get your nose within about 11 inches of the surface, something the astronauts could not do in their stiff spacesuits. Altogether, the three astronaut photographers took 48 slide pairs, and most of them show a surface structure you would never imagine from standing head height. The slides are strikingly beautiful, but the camera, like its originator, was a source of tremendous controversy.

Gold has spent his career in a veritable boxing match of scientific theorizing. He earned an undergraduate degree in engineering from Cambridge University in 1942, but he is essentially self-taught in the several disciplines in which he has had a significant impact. Physically, he would fit nearly everyone's stereotype of the absent-minded professor: somewhat shabby, glasses uncleaned, an air of vagueness. He's mild-mannered and soft-spoken with an unidentifiable European accent, and a bit stooped—except that when he's involved in a scientific argument, he seems about two feet taller. But the mind in that 81-year-old body is anything but absent. Ask him any question about a wide variety of specialized scientific fields and he will patiently explain a theory or a process either in the most lucid terms that virtually anyone can understand or in the complex jargon and mathematical formulas of the specialist, depending on who's asking. His knowledge of the minutest details of the physical and biological worlds is staggering. An afternoon with Gold is like a browse through an interactive encyclopedia.

His mind draws him to disciplines in which some experts do not consider him qualified. So far, his major efforts besides engineering have included physics, biophysics, astrophysics, astronomy, and geology—not to mention incursions into aircraft accident investigation and lunar photography. Gold's style is both unique and abrasive: He does his research and ultimately proposes a theory considered outrageous by the reigning experts in the field who first revile and then ignore him. Though some people credit him with spectacular mistakes, in the long run he is, more often than not, proven right.

When World War II started, the British sent Gold to a Canadian internment

MICHAEL GREENLAR



As the STORY GOES, TOMMY GOLD PREDICTED AS FAR BACK AS 1955 THAT THE SURFACE OF THE MOON WAS A MILES-THICK LAYER OF DUST AND THAT A LUNAR LANDER AND ITS CREW WOULD SIMPLY SINK OUT OF SIGHT. SITTING NEXT TO HIS NEW MACINTOSH G4 IN HIS VERY LARGE AND VERY CLUTTERED HOME OFFICE, GOLD INSISTS HE NEVER SAID THAT.

camp—his family, though German Jews, carried Austrian passports—but after nearly a year he was allowed to return to England. By then Hermann Bondi, whom he had met in the camp, was working with Fred Hoyle at the British Admiralty, where they were helping to develop radar. Gold became part of the radar development group. He tells stories about living with Bondi in a small house at the end of a runway used by heavily laden departing bombers, and only a hundred yards from the spot where damaged bombers dumped the bombs they had been unable to drop on German targets. The windows in their little house were often blown out. "Once I opened the door to my room just as a bomb went off," Gold says. "The violence of the explosion shattered the ceiling and I ended up with a giant piece of plaster in my mouth. Bondi said, 'Did you hear that?' "

After the war, Gold did research on the human ear that was discarded as "rubbish" by the experts. More than 30 years later new research proved him right while, by the by, proving a Nobel Prize winner wrong. Gold, with the collaboration of Hermann Bondi, generated the only scientific theory of the creation of the universe, besides the Big Bang theory, to achieve significant credibility. Though Gold's Steady State theory has been unpopular for the last couple of decades, it now shows signs of resurgence amid new debate over the Big Bang. He also formulated the generally accepted theory that pulsars are rotating neutron stars. He is particularly proud of being an Honorary Fellow of Trinity College, Cambridge, an honor shared with only a handful of other people in the world, among them the Duke of Edinburgh.

Gold is now professor emeritus in astronomy, physics, and applied physics at Cornell University in Ithaca, New York. Yet he still puts in a full work day and until very recently served as principal investigator for various contracts, including geophysical research into the origins of petroleum. While he has no current contracts, he is working privately on a problem in quantum theory, the solution for which he believes will have significant impact. And he's still controversial. Gold's 1997 book, *The Deep Hot Biosphere*, which proposes, based on his earlier contract research, cosmological rather than biological origins of oil, has petroleum geologists in a fury of rebuttal. If he's right, the future will hold an abundance of energy and the world economy will be consequently transformed. In all of these enterprises, Gold has taken punches from some of the best scientists of at least two generations and counterpunched quite effectively.

But it is his "deep dust" theory that plunked Gold into boiling water with other lunar researchers, and merely hot water with NASA and the astronauts. As the story goes, Gold predicted as far back as 1955 that the surface of the moon was a miles-thick layer of dust and that a lunar lander and its crew would simply sink out of sight in it. Sitting next to his new Macintosh G4 in his very large and very cluttered home office, Gold insists he never said that: "A long time ago, someone—it might have been Gene Shoemaker—misquoted me in the press, and everyone has been using that ever since."

Gold points to several passages in his articles that state clearly his views about the lunar surface as a fine powder. That dust, Gold theorized in 1955, was moved by electrostatic forces—electron bombardment gives the grains charges that cause them to repel each other and, thus, move downhill—from the upland craters to the mare, where it could be several kilometers deep. But, Gold says in a 1964 NASA-published article titled "Ranger Moon Pictures: Implications," ".... it is important to keep separate the discussion of the origin of the material and its present mechanical properties.... [I]t has often been implied that if the low ground is filled with dust sediment then it will be loose and soft to some great depth. This is no more a direct implication there than it would be in the Mississippi basin."

Don Wilhelms participated in the scientific debates surrounding the Apollo program and in 1993 published *To a Rocky Moon: A Geologist's History of Lunar Exploration*. Wilhelms is one of those who says that Gold insisted before the landings that deep dust would swallow any spacecraft. He says that Gold, with his denials after the landings and to this day, is recanting. "He never said it in print," says Wilhelms, "but everybody heard him say it at conferences and other places." When asked if he personally heard him say it, Wilhelms replies: "Oh sure," and he lists several instances in which other scientists refer negatively to Gold's hypothesis. He adds: "Gold's insistence on these ideas cost NASA a lot of time and millions of dollars because they had to investigate them."

The fundamental disagreement raged between the physicists and the geologists, with Tommy Gold as the lightning rod through which flowed much of the highly charged discussion. In the Apollo days, Bruce Hapke, a professor of planetary sciences at the University of Pittsburgh, had proposed, with Hugh Van Horn, a "fairy castle" model of the lunar regolith (fine pow-

▶ For more information on this story, please visit www.airspacemag.com

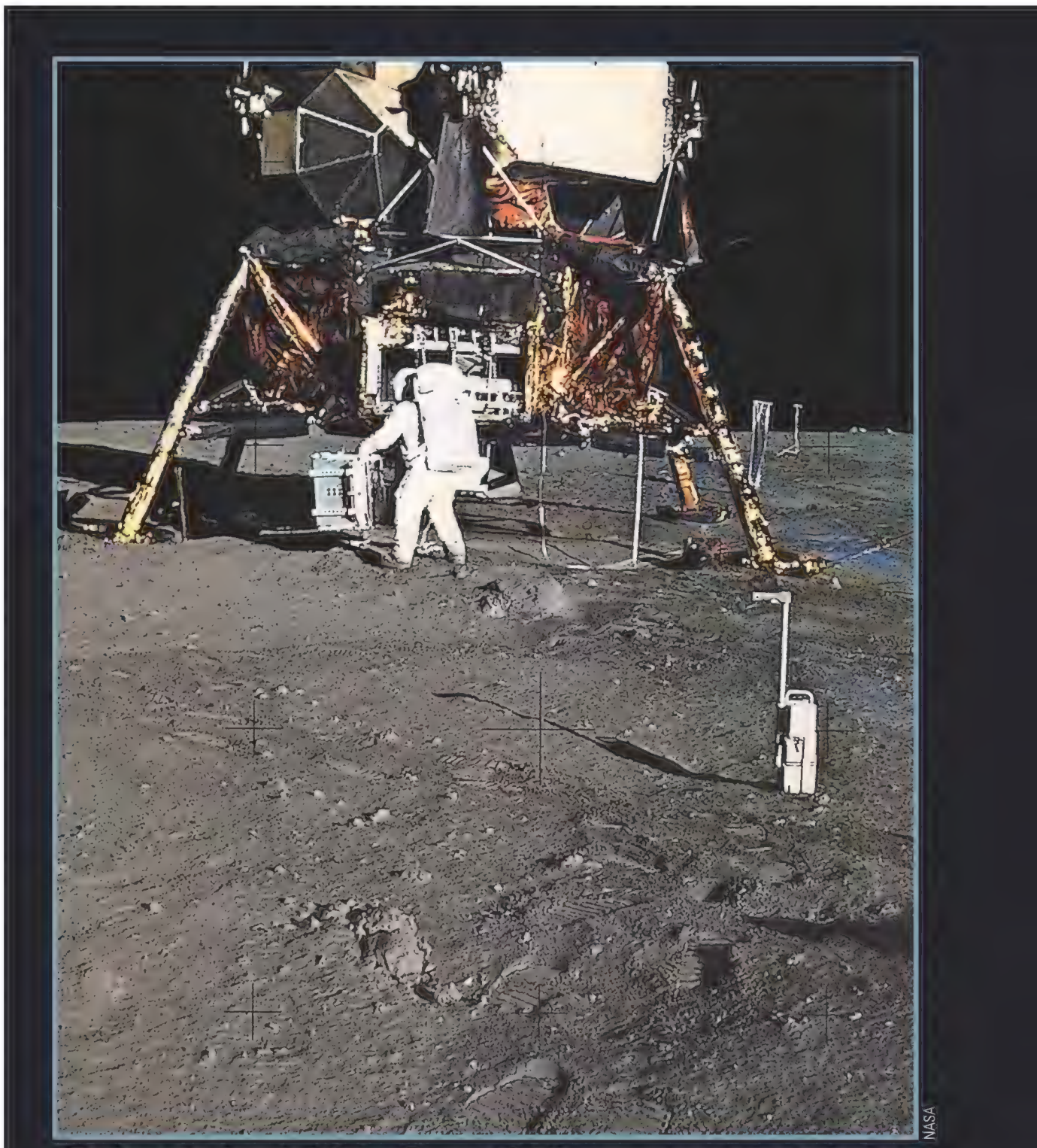
der). The theory described the first few centimeters of the surface as a fine powder consisting of "towers leaning at crazy angles and connected by lacey bridges and flying buttresses." The explanation was that molecular surface bonds were heavier than the extremely small particles, so that the adhesive forces formed these three-dimensional fairy castle structures. Hapke's model was usually—incorrectly, says Hapke—lumped together with Gold's deep dust model by the geologists and scorned in the same breath.

The ALSCC inevitably became part of the controversy. Critics proclaimed that the camera was simply Gold's desperate effort to keep "his" fairy castle hypothesis alive. Gold says he was concerned about what lunar samples would not reveal. "The one thing the investigation as it was proposed would not tell us was how the top surface material was emplaced," he recalls. For astrophysicists, the answers to such questions also provide small bits of data for the larger project of determining the nature of the universe.

Gold's considerable fame as a scientist had earned him an invitation in 1964 to join the President's Science Advisory Committee for Space, and he proposed his camera idea to that group. The committee members approved, and another committee was formed with such members as Edwin Land of Polaroid fame and Edward Purcell, a 1952 Nobel Prize winner in physics; Gold served as chair. The committee would provide the parameters and Kodak would be recruited to build the device. But there were complications.

Foremost was timing. It was November 1968 when Edwin Land talked to Kodak management about the camera. Chuck Spoelhof, who was then assistant to the director of research and engineering at Kodak, says that even though Kodak was very busy with Air Force contracts and had a shortage of personnel, "somewhat reluctantly we said okay. But a month went by and we heard nothing. Then a package came in the mail, several inches thick, containing a Request for Proposal with all the standard boilerplate for NASA procurement contracts. We realized there was no way we could meet those requirements and meet the date, so we sent back a 'no bid' to NASA. That shocked them." But NASA was determined and agreed to negotiations on abbreviated procedures and the shifting of responsibility to Kodak standards. Those negotiations ended just before the Christmas holidays, giving Kodak barely six months to design the camera and produce the required number of units—six flight models and four training models—by June 10, 1969, so the first one could ride on Apollo 11.

Bruce Elle, now deceased, was put in charge of the camera design group. Bill Wilson, project engineer in the group, says: "We were given a building of our own and isolated from the rest of Kodak so there would be no distractions." Besides the time limitation, the Gold committee's parameters were complex. For example, the camera had to be capable of withstanding temperatures of plus or minus 250 degrees, collapsible for storage in the lunar module, easily extendable by astronauts with fat gloves once it reached the moon, and as simple to operate as a point-and-shoot camera. It would have built-in flash for consistent lighting and a means of shutting out ambient light.



NASA

Mission afterthought? Using Tommy Gold's camera was a low priority for the Apollo astronauts, who shot only 48 images on the three missions that carried it. Here the camera sits as Buzz Aldrin retrieves equipment from the Apollo 11 lunar module.

COURTESY TOMMY GOLD/CORNELL UNIVERSITY (2)

The take-up film cassette had to be easily removable because the camera itself would be left on the moon to provide more space and weight for returning lunar soil samples.

The final product is a highly refined version of Gold's basement experiments: Inside the cowl at the base of the cane-like handle are two separate "cameras" at slightly different angles—about 11 degrees apart—a design that enabled center lines through both lenses to meet at a distance of about 11 inches, where the surface to be photographed would be when the camera was set down. The trigger on the handle operated both shutters simultaneously and set off the flash. With the camera's cowl shutting out ambient light, the flash ensured that the lighting of every picture would be optimal. The two resulting photographs, when viewed through a stereo viewer, would show the surface in an illusion of three-dimensional reality.

Though NASA was pleased with the camera's initial testing, the buck really stopped with the astronauts who would actually take the camera for a walk and snap the pictures. They were exposed to the camera in the training sessions, and Gold had a half-hour to talk to whichever astronaut on each mission was scheduled to handle the camera. And here the road was often as bumpy as the lava rock terrain the astronauts used for training. While there was no obvious hostility between Gold and the astronauts that could compare with the open and often expressed antagonism among the scientists, some tension was there.

Three decades have not diminished Gold's habit of referring to the astronauts as "prima donnas." He has a special place in the darker part of his heart for Alan Shepard, who "played golf instead of snapping pictures," and has never really overcome his disappointment over the small number of ALSCC stereo pairs—48 total for the three missions that carried the camera.

The images represent the only in situ *observations of lunar topography at millimeter scales. Some revealed fine granularity (top), others a mysterious glazing on many surfaces (left).*

For the ASTRONAUTS, GOLD WAS AN IRRITANT, AND FEW WOULD HAVE SAID THAT HE WAS THE SORT OF IRRITANT THAT PRODUCES THE PEARL. IN A RECENT EXCHANGE OF E-MAILS, NEIL ARMSTRONG ANSWERED NO WHEN I ASKED WHETHER THE ASTRONAUTS RESENTED GOLD. BUT HE ADDED: "WE OBJECTED TO THE CAMERA BEING PUT ON THE FLIGHT VERY LATE IN THE PREFLIGHT PROCESS WITHOUT NORMAL COORDINATION."

For the astronauts, Gold was an irritant, and few would have said that he was the sort of irritant that produces the pearl. In a recent exchange of e-mails, Neil Armstrong answered "no" when I asked whether the astronauts resented Gold. But he added: "We objected to the camera being put on the flight very late in the pre-flight process without normal coordination." Harrison (Jack) Schmitt, a geologist who walked on the moon with Apollo 17 and was mission scientist for some of the earlier flights, says much the same thing. "What bothered the astronauts the most was that this camera came in at the last minute and modified the training program. Most people don't realize how intense these training programs were, especially for Apollo 11, where we'd never done it before." He adds: "The only way anybody would agree to use it was to shoot targets of opportunity. If we had the time we'd pull it out and take a few pictures."

Alan Bean, who used the camera during Apollo 12, has a different perspective, perhaps because his mission included no hurried addition of the camera to the checklist. He says he would have liked to take more pictures (he took only 15), but the camera was the last thing on the checklist before extra-vehicular activity termination. Bean reads that section of his checklist aloud: "Stereo close-up photos. Retrieve ALSCC. Deploy skirt. Photo: unexpected features, glassy features, rock-soil junction up and down hill, undisturbed surface level and sloped, rock surface, boot prints, LM footpad, material adhering to boot, craters and clumps. Put film in equipment transfer bag." Bean adds: "We had seven minutes to do all that, from 2 plus 48 to 2 plus 55. Deploy the camera, get it ready, get the pictures, take out the film cassette. So you can see what kind of priority it had." Bean also praises the camera itself, as it was very astronaut-friendly. "You could just put it in the right place and pull the trigger."

Besides the camera, at least some of the astronauts had problems with Gold's science. Schmitt insists that Gold had no rationale for his theories about the lunar dust: "Tommy was flying in the face of what had already been proven erroneous, and he just wouldn't stop. But he could get the media to listen to him and rattle the cages of NASA headquarters people." Armstrong says succinctly: "We found the predictions of Dr. David Carrier and the Soil Mechanics team to be more persuasive than Dr. Gold's." Bean agrees that Gold's theories "were usually something that was detrimental to the possibility of having a successful lunar landing and exploration.... He was taking the negative side and we were taking the positive. It was frustrating, but it does make you do your homework."

But it's safe to say that the astronauts' principal concern was for "a safe lunar landing and exploration," which can be taken as Bean's euphemism for living. Most were not scientists and had no real involvement in the debate as science. But behind the scenes of preparation for the Apollo missions, the scientists were engaged in a war of theories. Ian Mitroff wrote a book, *The Subjective Side of Science*, published in 1974, about the scientific skirmishes waged in a period beginning just after Apollo 11 and ending after Apollo 17. He interviewed 42 major scientists working on the Apollo project and on lunar science. When asked why he gave the scientists pseudonyms, he responds: "Because the things they said about one another sometimes crossed the line into slander, often laced with profanity. I respected every one of these guys, but the number of times they told me to turn off the tape recorder—but I couldn't turn off my mind—and the F-words they said about one another were just incredible."

As part of that study, Mitroff classified his scientists into categories, ranging from high-level theorists to data-gatherers. He shows a clear preference, both in the book and in recent conversations, for the theorists with large ideas, the people who take the risk of being either spectacularly right or spectacularly wrong. He puts Gold in the theorist category. "There are two kinds of geniuses, the ordinary and the magical. The ordinary ones just have a bigger computer. The magical ones come up with things you can't imagine. Gold is what I'd call a scientific metaphysician. People like that take ordinary science and apply it to the universe in a way that's almost mystical."

Bruce Hapke has a different take on Gold. He believes that the source of the intense antagonism directed toward him was Gold's style. Gold was educated in the British system, in which it's considered good sport to destroy the opposition with wit and sarcasm; afterward you all go out and have a beer. American scientists, on the other hand, were simply offended. Mitroff's book has a quote from one of his subjects describing a colleague's behavior at a conference. "Once at a conference someone asked Park [pseudonym] a question at odds with Park's beliefs, and Park cut him to pieces with a joke. The audience laughed and the guy was dead, and Park carried on." He may have been describing Gold. But considering what Mitroff discovered about slander and profanity in his interviews, it seems that the only difference between Gold and his

COURTESY: TOMMY GOLD/CORNELL UNIVERSITY (2)

Studying clusters of larger rocks (above) helped scientists develop theories of the origins and movement of lunar soil. Kodak built 10 Gold cameras. One, a training model, is on exhibit at the National Air and Space Museum (below).

ERIC LONG

antagonists was that Gold did his dissecting in public.

Many of the principal players in lunar studies of the Apollo era are now dead—Eugene Shoemaker, Harold Urey, Gerard Kuiper—but the battle over the moon's surface composition, in the absence of further lunar missions, still rages. Wilhelms was a member of Shoemaker's astrogeology team, and he argues that virtually everything Gold said about the moon was wrong. And he still burns over a remark attributed to Gold: "Geology is so simple that someone like Kuiper [an astronomer] could learn it in a day." Hapke, while recognizing that Gold liked the limelight and tended to say outrageous things, generally credits Gold with good science. He says that the closest Gold ever came to saying there was "deep dust" was in warning that the transported dust might hide crevasses similar to those in the Antarctic snows. Most of the surface is solid enough, but if you step on the drifted covering of one of these crevasses you disappear. Gold, says Hapke, was merely erring on the side of caution. "He kept saying: 'Look, this is a new world. We don't have any experience with it.' " From the vantage of the year 2001, "Gold was closer to being right than anyone else," Hapke says. "It's time to give the Devil his due."

But it's still fair to ask whether the stereo photos have ever revealed anything of scientific importance. Gold responds: "What I learned that I didn't expect was the glazing." He is referring to a phenomenon observed by the astronauts and recorded in some of the stereo images in which the tops of some dirt clumps in the bottoms of small craters are covered with a glassy material. Gold proposed that a solar flash had heated the tops of the clumps enough to melt them into glass, which then dribbled partly down the sides of the clumps. Others have proposed solutions centering on the glassy material having been formed by the same impact that formed the crater or by the splattering of molten rock from a nearby event. Gold insists he is right. "The idea that this was caused by impact is ridiculous. The craters were due to impact, but the clumps are very fragile

The astronauts photographed undisturbed soil as well as boot prints and lunar rover tracks (as above) to demonstrate the soil's cohesive properties. Not even they had such a close view of the surface—until they saw the photographs.

"*Gold* WAS CLOSER TO BEING RIGHT THAN ANYONE ELSE. IT'S TIME TO GIVE THE DEVIL HIS DUE."

and would be destroyed by the slightest impact." He adds: "I still regard that as a very important discovery." And, of course, it is clear that the astronauts could not possibly have brought back any of those clumps intact, so the photographs remain the only means of studying the phenomenon. Several articles by different authors were published in *Science* and *Icarus* on this subject in the years immediately following Apollo 11.

The photographs also show another curious phenomenon. Gold describes it: "On the occasions when [the astronauts] heaved out a stone, a third of it was embedded in the soil, but there were no features to indicate from where the stone came in: no earth piled up on one side and no depression on the other. That indicated to me enough migration of surface grains to even out the soil. There is an even one-centimeter-high junction of the soil with the rock all around the stone." Gold has used this observation as partial support for his theory of electrostatic transport. There was no way of bringing back a rock embedded in its surrounding soil, so again, the photographs remain the only means of study. Unfortunately, not one of the photographs can be identified as corresponding exactly with a lunar sample returned to Earth. Such a happy conjunction might have provided valuable information.

In 1999, Paul Helfenstein, a space scientist at Cornell University, and Michael Shepard, a geologist at Bloomsburg University in Pennsylvania, published an article in *Icarus*, "Submillimeter-Scale Topography of the Lunar Regolith," in which they listed several studies by Shoemaker and others based on the 3-D photographs. Helfenstein and Shepard have used the stereo pairs to produce digital topographic maps to compare against radar and photometric studies of the lunar surface.

The Gold camera was dropped from the last two Apollo missions for a variety of reasons: continued opposition from the astrogeologists, increasing competition for space for scientific experiments, and perhaps a feeling that Gold had had his turn. The camera Gold keeps at Cornell is the one that was scheduled to go on the Apollo 15 mission. It sits forlornly on the top of a bookcase, and the slides from missions 11, 12, and 14 are all jumbled in a box, some of them with broken glass. Another Gold camera, a training model, is currently on display at the National Air and Space Museum. The rest of the most expensive hand-held point-and-shoot cameras ever made rest lightly on the surface of the moon (though one, placed aboard the aborted Apollo 13 mission, now sits somewhere at the bottom of the Pacific Ocean). One of them has stick-on lettering that says: "Return to Bruce Elle, Eastman Kodak Co., U.S.A., Earth." But if you can wangle yourself a trip to the moon, two more are available.

Astronauts to Asteroids

Thomas D. Jones

We've done the moon. Mars is too far. There's a better destination in our own back yard.

For most of the 1990s, then-NASA Administrator Dan Goldin enthusiastically endorsed the idea of sending humans to Mars. But in the end, he couldn't deliver the political mandate or the funding to venture anywhere beyond Earth orbit. New administrator Sean O'Keefe, straightjacketed by budget problems, has so far avoided the topic of "Where next?" That leaves advocates of human space exploration wondering where NASA is ultimately headed, and how soon we might get there.

I came face to face with this struggle over "the vision thing" more than a year ago, just 30 minutes before suiting up for my launch on *Atlantis* to the International Space Station for mission STS-98. In the astronaut quarters at Cape Canaveral, Florida, Joe Rothenberg, then NASA's chief of human spaceflight, flatly told me and my crewmates that he saw little chance of astronauts rocketing out of Earth orbit for at least 10 to 15 years.

I was shocked. About to strap on a rocket and head for the space station, my boss had just told me that NASA was essentially marking time. Wasn't it his job—and the Administrator's—to develop public and political support for more ambitious projects? NASA was clearly intent on not rocking the boat; rather than propose bold new initiatives, it would simply wait for direction from the top.

Now the president and nation are preoccupied with a war, and budget surpluses are proving ephemeral, so any near-term goal for space exploration will have to be both practical and affordable. Thirty years after the last lunar landing, what might that destination be?

The answer came into focus for me on February 12, 2001, during my second spacewalk outside the space station. Falling around the planet at five miles per second, my space-suited hand

DAVID POVILAITIS

gripping a gold handrail on the station's *Destiny* laboratory module, I had one of those moments that crystallize into a permanent memory. The event that grabbed my attention was happening almost 200 million miles away, where a spacecraft called NEAR Shoemaker was making history.

As Bob Curbeam and I worked on outfitting *Destiny's* exterior, mission controllers outside Baltimore, Maryland, eased the robot orbiter toward the surface of an asteroid called 433 Eros. The spacecraft had rendezvoused with Eros a year earlier and was now ending its mission with a spectacular gamble—a landing on one of the oldest objects in the solar system. Beamer and I had just uncovered *Destiny's* new research window when our radios crackled with the astounding news that NEAR Shoemaker had bounced down on Eros' dusty terrain—and survived. In my spacesuit, sweaty with exertion, I was hit by a shiver of excitement, imagining what it would be like to spacewalk not in Earth orbit but a million miles away, drifting over the rubble-strewn surface of a near-Earth asteroid (NEA).

Today I'm even more convinced that these intriguing objects are the next logical destination for NASA after it finishes building the space station. Unlike a three-year voyage to Mars or establishing a base on the moon, journeys to near-Earth asteroids can get us back in the business of exploring *terra incognita* soon. And whatever we learn from an asteroid mission would be invaluable to future exploration of the moon and Mars.

What makes NEAs so attractive is their accessibility. Over the past ten years, astronomers have discovered hundreds of asteroids whose orbits around the sun bring them close to Earth. Many are easily reachable with only modest improvements in spaceflight technology; in fact, some are easier to reach than the moon. Already we know of a handful of NEAs that would require less than a year—round trip—for astronauts to explore, and reaching them would use less rocket fuel than a visit to the lunar surface. The flight times are shrinking almost daily. Last year, for example, Leon Gefert of NASA's Glenn Research Center in Cleveland, Ohio, found that a round trip to 1991 VG, a small NEA only tens of meters across, would take as little as 60 days, with half the time spent exploring the asteroid. Astronomers believe there are hundreds of similar objects out there, waiting to be discovered.

Now, for the first time, we're talk-

entary

ing about journeys beyond the Earth-moon system that are well within the range of *current* human spaceflight experience. Many cosmonauts and astronauts have already spent more than 60 days in space with no serious problems. "Weekend getaways" to asteroids would be even shorter than a typical tour of duty on the space station, and minimizing exposure to microgravity, cosmic radiation, and solar flares might reduce health risks. Since the astronauts on an NEA mission would never stray more than a few million miles from home, they could abort directly back to Earth in case of an emergency, and be home within weeks.

It isn't enough, of course, to say we should go to asteroids just because they're easy to reach. What would such a project offer the nation as a "return on investment"? One payoff would be scientific: Asteroids offer a rich and untapped store of knowledge about the early solar system. An array of asteroid samples, chosen intelligently by field explorers, would tell us how the original stuff in the solar nebula coalesced into planets and other rocky objects billions of years ago. Robotic sample-return missions couldn't harvest as much material; nor would we expect robot missions to return samples of the same scientific value.

There may also be an economic reward. Asteroid missions would assay natural resources that may eventually help us reduce the horrendous cost of space exploration. For example, the space shuttle currently hauls supplies to the station at a staggering $10,000 a pound, with much of the load being water and propellant. Some NEAs are composed of clay minerals that contain up to 10 percent water. Extracting it and turning it into hydrogen and oxygen rocket propellant may some day prove cheaper than dragging it up from Earth.

Exploring asteroids could also serve as a practical hedge against the impact threat. In January of this year, an NEA called 2001 YB5 swung within 400,000 miles of Earth, less than twice the distance to the moon. Had this stadium-sized boulder hit Earth, it could have devastated a region as large as the coastal states from New York to Virginia. An NEA mission could provide structural and composition data that would enable us to devise a practical scheme for diverting an asteroid should one threaten us.

Voyages to asteroids represent a natural progression in difficulty, more challenging than the dash-for-the-moon Apollo missions, but less daunting than a multi-year Mars expedition.

Finally, sending astronauts to NEAs gets us moving toward Mars. As a spacefarer, I find that the greatest attraction of the "astronauts to asteroids" idea is that all the development costs would directly benefit an eventual Mars expedition. The spacecraft used for an NEA mission would have to do nearly everything required of a Mars ship, save for the landing itself.

NEA voyages represent a natural progression in difficulty, more challenging than the dash-for-the-moon Apollo missions but less daunting than a multi-year Mars expedition. So think of an NEA mission as a shakedown cruise for a Mars trip: the 21st century equivalent of Apollo 8 or Apollo 10, valuable rehearsals that greased the skids for the first lunar landing.

It's time to make a cogent case for moving out of Earth orbit again. The reality is that Congress is not going to hand over $100 billion for a push to Mars anytime soon. NASA must offer the nation a goal that's new and exciting, doable in the near term, and affordable. I estimate that if we capitalize on experience gained from the space station, we could mount several manned NEA expeditions for about $3 billion a year over the course of 10 years—about the same as the station's initial construction costs. By way of comparison, $3 billion is less than five percent of the U.S. Department of Agriculture's annual budget, or half of what American consumers paid for video games last year. We can afford the investment.

To get rolling, we should enhance existing ground-based asteroid search programs to identify attractive, easily reachable targets. NASA should mount robotic precursor missions to NEAs while defining the scope and cost of human expeditions. And focused research should continue on the space station to address the health hazards that will confront astronauts on a deep-space mission.

One challenge, though, is easy—what to name the asteroid expedition. The first voyage beyond Low Earth Orbit (LEO) since Apollo should be called *Virgo*, after the sixth constellation in the zodiac. Why *Virgo*? The name evokes a leap into virgin territory, yes, but the clincher is in the stars: As the sun crosses into Virgo in late summer, it leaves Leo inexorably behind.

Tom Jones is a planetary scientist, writer, consultant, and former astronaut. Before leaving NASA last year, he flew on four space shuttle flights, racking up three spacewalks and 53 days in orbit.

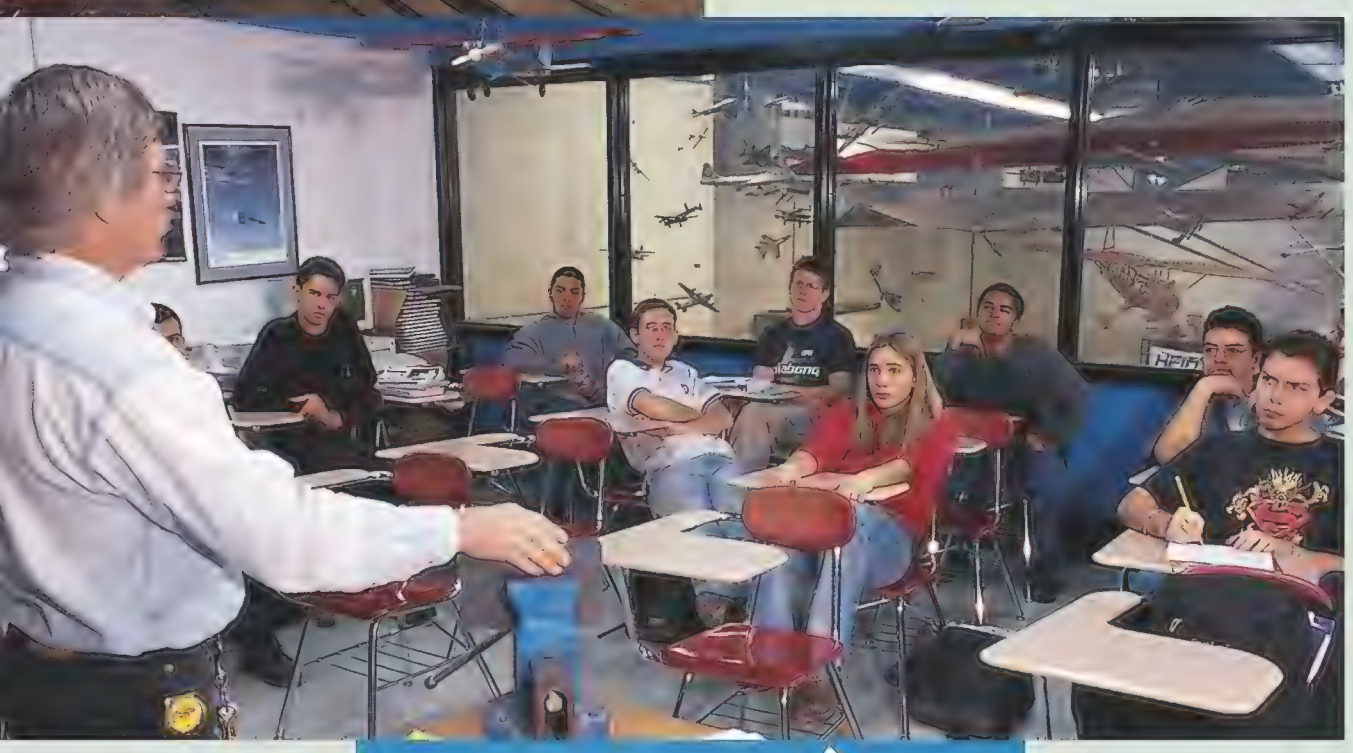
shop class

The airplane builders of Mundelein High

BY JOHN FLEISCHMAN | PHOTOGRAPHS BY DEAN LA PRAIRIE

I was never like this

Opposite: An assortment of model aircraft hover inspirationally over the students in Jim Jackson's Aviation Technology class. Below (top to bottom): A student cuts metal; Jackson gives a lesson on wing construction; Mundelein's second airplane, a Kitfox, surveys the scene at a homecoming game.



OPPOSITE BOTTOM: COURTESY JIM JACKSON

Late in the summer of 1999, two enormous wooden crates arrived at Mundelein High School, in the northern suburbs of Chicago. Inside were 30 blueprints, three thick instruction books, and the makings of a composite-material, high-speed, four-seat monoplane. Soon after, another box arrived, this one containing a 325-horsepower Continental IO-550-N engine, assembled but lacking fuel, throttle, propeller, and instrument connections.

Last December, roughly 3,000 labor-hours later, senior Sayre Kos was crouched in the cargo bay of what had become the fuselage of a Super Lancair ES. Kos was contemplating the placement of the master solenoid hatch cover. The top of the fuselage was off, and Kos' teacher, Jim Jackson, was peeking in over the side and asking Kos to consider where the solenoid wires were going after they left the switch box. Those thick volumes of instructions showed the theoretical circuit but not the actual path.

Already the roughed-in cockpit was sprouting a dense undergrowth of cables and wires. To get through that tangle, Jackson explained, you wanted the solenoid wiring to have the fewest kinks and the straightest path possible without getting in harm's way. Kos, who'd spent most of a week building the fiberglass hatch cover, now had to make sure that its placement wouldn't interfere with the solenoid's exit hole so that in the afternoon class of Aviation Technology, another student could pick up the next stage of the cable's journey unimpeded.

Kos moved the cover around until he was satisfied there was room. He marked the mounting points. "That looks good, Mr. Jackson," he said.

"No, it looks professional," said Mr. Jackson.

Since 1980, Jackson's Aviation Technology classes—the "Mundelein High School Airplane Factory," as he and his students call it—have put together five commercial build-your-own-airplane kits. The buyers of the airplanes are private sponsors who have put up the cash for the kits; in return, they get a handmade aircraft without having to pay any labor costs.

The sponsors must sign off on all liability. But the Mundelein airplanes do come with a guarantee of sorts: Mr. Jackson. Even though the building is done by students, "you know he's in there at night working his tail off to make sure everything was done right," says Kos.

Getting high school students to work is a bit like herding cats. Last December I watched as Jackson somehow got 16 of them to slowly wake up, listen to a short lesson on welding, and then declare their targets for the day's shop time. "Any questions?" he asked. "Okay, let's get to work." The students headed out into the shop, which rapidly filled with the sounds of sawing, grinding, and hammering. Jackson dispensed tools, advice, and the occasional mild caution.

The Super Lancair ES was to be the last Mundelein airplane for Jackson, who retired at Christmas. But it will not be the last Mundelein airplane. A teacher named Cory Owens has since taken over the school's aviation program, having satisfied the

school board's daunting Vacancy Notice requirements: an Illinois teaching credential, plus a private pilot's license and/or an airframe-and-powerplant mechanic certificate from the Federal Aviation Administration.

The airplane assembly classes are part of the school's Industry and Technology vocational program; students can take the courses to prepare for careers as aircraft mechanics. That's a smart choice these days. The U.S. Bureau of Labor Statistics expects the supply of aircraft mechanics and avionics technicians to tighten over the next 10 years as fewer candidates are produced by the military and a wave of Baby Boomer retirements sweeps through the U.S. aviation industry. The Aviation Technician Education Council, a coalition of trade schools that train aviation maintenance technicians (AMTs), goes further, saying that there is already a shortage of young AMTs training for entry-level positions. The big airlines will probably do all right, says council vice president Richard Dumarescq, because they pay top dollar, but regional airlines and general aviation businesses could be facing a crisis in five to seven years, when so many AMTs now in their 50s start to retire.

Before taking Jackson's course, Robert Hanrahan says he had "absolutely no idea of the possibilities in the aviation industry whatsoever." He recalls: "I'd heard about the program from some of my friends, but I thought maybe they were building model airplanes or something. I had no idea they were building a real one. One day though I'm walking by and I go, 'Whoa, there's an airplane in there.' After that, I had to check it out." (It's not an uncommon story. Says Brian Thatcher, head of the school's guidance department, "Jim has taken a passion of his own and turned it into a course that pulled in all sorts of students over the years.")

In Jackson's class, Hanrahan worked on the Super Lancair ES, helping install the engine mounts on the firewall and then mate the Continental engine to the airframe. He eventually was bitten deep by the airplane bug. In the spring of his senior year, he took flying lessons and got his private pilot's license. He hopes to get his instrument rating this summer. Though he is now majoring in pre-law at Michigan State University in East Lansing, he says: "In ten years I hope to be in the first chair of a 737 or 757. If I can find a triple seven [777], I'll be there."

Senior Maggie Olczyk also fell under the aviation spell while working on the Super Lancair ES. She ended up taking flying lessons and applying to Embry-Riddle Aeronautical College in Daytona Beach, Florida.

Both Olczyk and Hanrahan look forward to the first flight of the Super Lancair ES so they can take part in a Jackson tradition: Whenever an aircraft is completed, Jackson serves as the test pilot, and the first passengers are students who worked on the project in class, earned at least a C, and went on to train for an aviation career.

"I can't wait," says Olczyk. "I'm just waiting for the phone call from Mr. Jackson. My friend and I worked on that part where you put your foot to climb into the plane. We did most of that, so if anything happens, they'll know who did it."

Jackson's campaign to introduce students to aviation has extended beyond shop work. As part of Young Eagle Days, a program that the Experimental Aircraft Association runs to encourage kids to try flying, Jackson would offer all his students, regardless of their career goals, a ride in a rented Cessna. Students vividly remember swooping down on Mundelein. Says one: "To see your own town from the seat of a small airplane—I mean, it's something you never forget."

To help broaden their perspectives, Jackson would bring a few students to the annual EAA fly-ins at Oshkosh, Wisconsin, to participate in exhibits on the Mundelein program. And each summer he took students on a fishing trip to a remote lodge in northern Ontario, where they'd go on short flights in one of the Mundelein airplanes. "My focus here has been to get young people to get away from Mundelein and see the world," Jackson says. "Some of these kids have never flown. Some of them have never been to Chicago.... I try to open their eyes a little."

Jackson with Mundelein airplane no. 4, a Montana Coyote.

The teacher about to take off in no. 3, a Lancair 360.

Students say that Jackson's lessons went beyond aviation. "He's taught me a lot of things about life in general," says Olczyk. "He incorporates a lot of things in his classroom, and I know that after taking his classes you have to be prepared not only to work together but to communicate."

Top: Assembling the fuselage of the Super Lancair ES. Above: Jimmy Sanders positions a piece of metal for welding.

Putting high school students to work is a bit like herding cats, but Jim Jackson somehow got them to wake up, listen to a short lesson, and then set off to buff, weld, and hammer.

The Mundelein High School Airplane Factory was conceived in the early 1970s, when Jackson was primarily the school's gymnastics coach. He wanted to fly, but he was unable to afford an airplane, so he decided to build one. In 1973 he drew up his own plans for a half-scale World War II-era P-51 Mustang and starting building it in his home shop. "We used to call it the Coffin," says former student and gymnast Doug Bartlett. "I saw it when it was four pieces of wood laid out on a piece of paper. We used to say he was going to kill himself in that thing."

The P-51, powered by a VW Beetle engine, was ready before Jackson could complete flight school. Impatient to test his work, he enlisted the one person he knew with a pilot's license, Bob Lotter Jr., a Mundelein senior who had soloed the summer before and was helping his father build an airplane at home. All Jackson needed him to do was taxi the airplane—just run up and down the strip at Campbell Airport in nearby Grayslake, he said. After that, Jackson intended to go over every bolt and fastener in the aircraft before the first flight. For safety's sake, he tossed Lotter a football helmet. It would be good enough for taxiing, Jackson figured.

Lotter obediently ran the P-51 up and down the strip a few times. Then he swung around and tossed out the helmet. It was hurting his head, he shouted to Jackson. The young pilot then gunned the throttle, shot down the runway, and, while the teacher looked on in disbelief, took off.

"I felt sick," Jackson recalls. "Here I was responsible for killing one of my students. I just prayed he'd come right back, but 10 minutes went by, and then 20, and no sign. I was sure at this point that the engine had cut out and Bob was down. Then after about a half-hour, he comes back and performs three barrel rolls directly overhead before he lands. The only thing he said to me was 'It's a little tail-heavy. Move the engine forward.' And he jumps in his car and drives off."

The class modified the Montana Coyote for rough flying conditions. Right: Jodi Miller learns how to polish the Super Lancair's wing.

Lotter went on to become an aeronautical engineer. Jackson went on to get a pilot's license. Eventually, he also got an FAA airframe-and-powerplant mechanic certificate.

To set up Mundelein High's Airplane Factory, he first found a sponsor, the owner of a skydiving landing zone who'd always wanted an acrobatic biplane. Then he talked the school board into accepting the deal—$20,000 cash up front for an Acro Sport II kit and engine, special tube-bending gear, fire insurance to cover the airplane while it was on school property, plus an ironclad pledge from the sponsor that he would not involve the school in any extra cost or any liability.

The work began. The Acro Sport was a metal-tube-and-fabric design with wood spars and ribs. "Only 'A' students welded on that one," Jackson recalls. It was six years before *Mustang Fever* was ready for a big flight.

Six years is a long time in high school generations. By that time, many of the kids who'd bent tubes and sanded ribs in 1980 were long gone. But when Jackson put out the word that the aircraft would be making a major flight, to the EAA fly-in at Oshkosh, the builders appeared from near and far at Campbell Airport. "The kids were jumping up and down when I took off," Jackson remembers. "They were screaming 'It flies! It actually flies!' "

The second airplane was *Bush Buster*, a Kitfox monoplane that was much simpler than the Acro Sport, even with wings that folded for transport and floats for hopping the lakes in backwoods Ontario. Trailered north behind a pickup each summer, *Bush Buster* served as the workhorse on Jackson's summer fishing trips, and over the years probably hauled more Mundelein students on puddle jumping flights than any of the others.

The third airplane was a major step up in materials, techniques, and cost. The Lancair 360 was a sleek two-seater built of composite materials and capable of 250 mph. It took five years to complete, emerging in gleaming Porsche red. "We hand-polished that aircraft until you could see your teeth in it," Jackson recalls, adding, "Of course, I had a lot of hands to do the polishing." The fiery red *Spirit of Mundelein* became an airplane with a mission. Flying in northern Ontario had given Jackson a taste for high latitudes, and he thought the *Spirit* was just the airplane to make the next leap: a trip to the Arctic Circle. He recruited Tom Lentz, a former student who'd earned his pilot's and instructor's license, to come along.

While the students in his Aviation Technology classes slowly built the airplane in the shop, the students in his Aviation-Aerospace class, essentially a year-long ground school, laid

out the flight plan. Jackson sketched out his general course: northwest to Grand Forks, North Dakota, through Customs at Edmonton, Alberta, and then to Yellowknife in the Northwest Territories and on to the Mackenzie River Valley. They would follow the icy Beaufort Sea, Jackson had a momentary jolt: "There I was, seeing the polar ice cap in a handmade airplane and about to land on a gravel military strip in a plastic airplane built by 16-year-olds."

The landing was a piece of cake. The two fueled up and had their logbooks au-

The builders fit floorboards for the Super Lancair's rear seat.

COURTESY JIM JACKSON

Mundelein's first airplane, a natty Acrosport, shows off the students' skills at a nearby airport.

valley to Tuktoyaktuk, an Inuit village on the Beaufort Sea. "[The students] had to figure out exact directions, refueling stops, and landing zones," Jackson says. "They also did my alternative backup plan. In the end, we followed it more or less exactly."

On July 9, 1994, Jackson and Lentz circled the *Spirit of Mundelein* over a former Royal Canadian Air Force field at Tuktoyaktuk. Looking down at the

Whenever the class completed an aircraft, Jackson would serve as the test pilot and the first passengers would be students. One says: "To see your own town from a small airplane—it's something you never forget."

thenticated (which later enabled them to earn an official world speed record: from Kenosha, Wisconsin, to Tuktoyaktuk). Then, wary of the weather, they took off within an hour, hopping southward as planned for Juneau and then the Inland Passage to the Lower 48.

The return flight was more leisurely. At the start of the last leg, Jackson called home from a pay phone outside Yellowstone National Park in Wyoming. He told his wife Judith to put out the word: The *Spirit of Mundelein* was returning home in triumph. It was summer. Jackson and Lentz figured that with such short notice, the only people who would show up to meet them would be their families and maybe one or two students. Instead, there were a dozen airplane builders. Says Jackson: "I lined them up right by the plane and I shook each one by the hand and said, 'Your part worked.' "

The fourth airplane was *Glacier Express*, a Montana Coyote kit for a light, rugged, short-takeoff-and-landing bushplane. The project began with a geologist from Northern Illinois University who was making annual research trips to Glacier Bay National Park in Alaska to study global warming; he thought such an airplane would be a vast improvement over the expensive small planes that he had been hiring. The *Express* would have folding wings for trailering, plus floats and skis. Jackson made 30 changes to the original kit in order to make the airplane better suited to the geologist's needs: He provided more visibility, extra fuel, more storage space for scientific equipment, and a strengthened tail for the floats. He even enlisted the assistance of an art teacher, whose students painted murals of the Johns Hopkins Glacier along each side of the fuselage. In the end, though, the geologist couldn't convince his funding source, the National Science Foundation, that he needed his own land/snow/water-capable airplane. A private sponsor took over the project.

According to the plan, the last Jackson airplane from Mundelein High School, the Super Lancair ES, should be test flown this summer. But the builders' confidence will get its ultimate test in April 2003. Weather willing and aircraft ready, Jackson will fly from suburban Chicago over the North Pole and back. His copilot and sponsor will be his old gymnastics student, Doug Bartlett.

The aircraft is being modified for arctic conditions. Instead of a back seat, it will have room for a fuel bladder, plus extra wing fuel tanks. A fixed landing gear was judged better for gravel strips than the retractable gear that came with the kit. The pilots will have nasal tubes to provide oxygen at high altitudes in the unpressurized cabin. And the avionics will be awesome and expensive.

Because he wanted to let Mundelein's new aviation teacher set his own course, Jackson moved the Lancair from the high school to a private shop after retirement. He is completing the airplane himself.

Finishing the airplane and getting it rated airworthy are only the first steps of the trip. The two pilots have to rack up time together at the controls and hours on the engine. Because the polar region's winters are so severe, barrels of aviation gasoline have to be transported by barge during the summer to be in place on remote Canadian military strips by the spring of 2003. Survival gear has to be selected. A flight plan, including emergency alternatives, has to be mapped out. A long sequential list of things to do—it's Jackson's idea of blissful retirement.

Jackson's lessons went beyond aviation. "He's taught me a lot of things about life in general," says one student. "You have to be prepared not only to work together but to communicate."

Co-adventurer Doug Bartlett, who is now running his family's electronics manufacturing business in nearby Cary, says he had to think a while about the risks before committing to the North Pole foray. Private pilots at the Arctic Circle are at the edge of the known world. To fly north of the circle is to fall off the edge—beyond land, beyond weather reports, beyond rescue. As an airplane approaches the Pole, conventional navigation goes out the window. Jackson and Bartlett will have to get up there, prove that they were there, and get back, all without landing.

On the other hand, Bartlett didn't have to think long about putting up the cash to fund the construction of the airplane. It's a good investment, he believes. He figures he will spend about $150,000 for the Super Lancair ES; by contrast, had he opted to have the aircraft fully assembled by the factory, he would have paid about $300,000.

But the real investment Bartlett wanted to make was in his former teacher. He still recalls Coach Jackson's gymnastics workouts at Mundelein: "At Iowa State, Jim was a runner-up ring man in nationals, and he brought that competitive spirit to the gym," he says. "When we were in the gym, he did not understand why each and every one of us did not want to be an Olympic gymnast.

"I figured there were other kids like me at Mundelein, kids who just needed a project to give them a little spurt, and I figure that Jim's aviation program does that," he adds.

Nominally, the polar flight is a tribute to the centennial of the Wright brothers' first powered flight. In truth, it is the final proof of the Jackson method. "If you show somebody that you can start out with one of these instruction books that have thousands of simple directions and complete them in an orderly fashion, you can do some fairly significant things," Bartlett says.

TODD BUCHANAN

Top: Jackson preflights an airplane before one of the free flights he offers his students. Above: The Lancair 360 after its record-breaking trip.

"That's one of the biggest lessons that Jim teaches. Complicated tasks and challenges in life are nothing more than a series of small steps, well thought out, and the discipline to continue on with them."

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SIGHTINGS

When it comes to its own recent past, the U.S. military tends to be unsentimental. Facilities and machines that are no longer in service—but which many deem historically significant—are usually reused or destroyed in the interests of space and money. Since 1998, Florida-based photographer Art Maples has been documenting significant relics of the cold war before the inevitable occurs. He has so far traveled to 12 facilities and intends to publish and exhibit the results. "I've always been interested in these often desolate, abandoned sites," he says, "and so few people have ever seen these places."

In Nevada, Maples found the Huron King Test Chamber (top), in which the military in 1980 tested space-based equipment for resistance to different types of attacks. Satellites and other devices were placed in the chamber, and then a nuclear device was detonated beneath it. Within seconds, the chamber was winched out of the way on its giant tank treads, saving the equipment from being swallowed up in the crater that quickly formed as a result of the underground blast.

In Nekoma, North Dakota, Maples located the Stanley R. Mickelsen Safeguard Complex (bottom), which was the only anti-ballistic missile facility ever built by the United States. It was to be the first phase of a 12-installation defensive system, and was designed to protect North Dakota's Minuteman missiles from enemy missile attack. Completed in 1975, the facility operated for only five months before being shut down. The site included an 80-foot-tall reinforced-concrete building designed to track incoming missiles by radar and guide the Spartan and Sprint interceptors. The structures to the left are ventilation shafts for the building.

The Zeppelin's Long Shadow

Zeppelin! Germany and the Airship, 1900–1939

by Guillaume de Syon. Johns Hopkins University Press, 2001. 288 pp., $29.95 (hardbound).

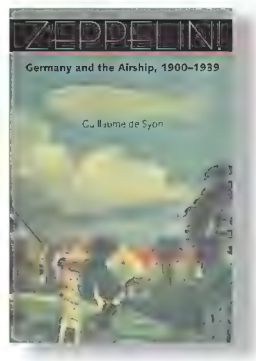
The Graf Zeppelin, here in its home port of Friedrichshafen, Germany, circled the globe in 1929. Zeppelins made an enormous impact throughout Europe.

What did people feel when they saw a zeppelin slowly sailing across the horizon? For nearly 40 years at the beginning of the last century, the sight held people's rapt attention. The majestic size of the zeppelin must have overwhelmed the senses; the grace of its movement across the heavens was like nothing else, and its implied military potential awed the citizenry of Europe.

The societal and technological importance of this aeronautical marvel has, for the most part, been relegated to the backwaters of historical texts. There are many reasons, but perhaps the simplest explanation is the demise of the zeppelin. But why did use of this technology cease so abruptly and at the zenith of its potential? Was it only the destruction of the *Hindenburg*? In this comprehensive work, Guillaume de Syon manages to express in clear and concise terms the importance of the zeppelin to Germany and to the rest of the Western world. He takes the reader through the lineage of powered airships, up to designer Count Ferdinand Graf von Zeppelin's initial efforts in Germany. We see the technical aspirations and the behind-the-scenes rivalries of the airship era, and also the relationship between airship development and German society.

The zeppelin itself is a powerful metaphor for Germany's military aspirations and its technical prowess and place in the world. The big airships came to stand for leisure and luxury—they were among the very first air transports, both domestic and international, to carry passengers—and then war, carrying World War I to the population of England. Though the zeppelin was more effective at instilling psychological terror among civilians than actually delivering ordnance, it cut a path soon followed by the long-range strategic bomber. In peacetime, dirigibles attracted an audience of admirers, but nowhere were there more admirers than in Germany.

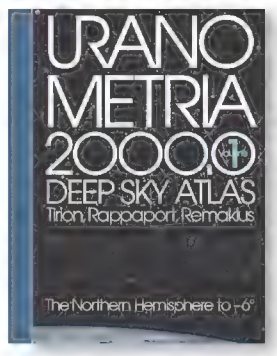
The author reveals new information and insights, including a description of the first aluminum-clad airship, which German manufacturer David Schwarz designed and built for Russia in 1894. Although a failure, it would influence Count Zeppelin's choice of construction material for his own airships. The book also reveals the dynamic politics behind the zeppelin. These include the Nazi elite's disdain for the airship—they deemed it fragile, unsafe, and less effective than traditional aircraft—coupled with their tacit use of it for propaganda purposes. The intricacies of backroom deals within both U.S. and German political structures come to light after the infamous destruction of the *Hindenburg* airship. Non-Nazi German politicians and businessmen failed in attempts to buy helium from the United States, which has the world's only deposit of the gas. The Nazis then used the *Hindenburg* explosion as an excuse to shift all the zeppelin manufacturing resources toward other war needs. The airship's reign would end only with the Nazis dominating Germany. This is one of the more interesting aspects of the zeppelin's history covered in this fascinating book.



Zeppelin! contains copious notes and appendices, as well as thoroughly captioned (and some previously unpublished) images. The quality of its scholarship is reminiscent of recent works that deal with broad views of aviation history, such as John Morrow's seminal *The Great War in the Air*. Overall, *Zeppelin!* fills a gap in the history of powered lighter-than-air flight, as well as in the history of early flight's effects on culture.

—Carl Bobrow is a specialist in the Collections Processing Unit of the National Air and Space Museum's Paul E. Garber Facility.

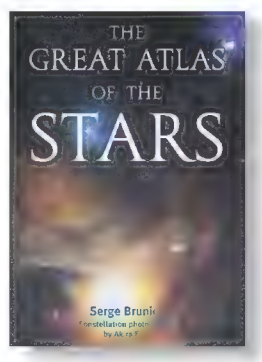
Uranometria 2000.0



by Wil Tirion, Barry Rappaport, and Will Remaklus. Willmann-Bell, Inc., 2001. Vol. 1, The Northern Hemisphere, *336 pp., $49.95; Vol. 2,* The Southern Hemisphere, *366 pp., $49.95; Vol. 3,* Deep Sky Field Guide *by Murray Cragin and Emil Bonanno, 546 pp., $59.95 (all hardbound).*

The Great Atlas of the Stars

by Serge Brunier and Akira Fujii. Firefly Books, 2001. 111 pp., $49.95 (spiralbound).



In the age of computerized everything, it's hard to imagine that sky observers would spend much time or money on star atlases. They can buy, often cheaper, planetarium software that shows and prints charts with all the constellations, stars, galaxies, and other celestial objects visible from their location at any given minute of the year and at any desired magnification. The software also just as easily shows the location and visual characteristics of all the planets—which printed sky charts can't do since the planets' positions change from night to night.

In spite of the computer age, it's very likely that these two new, completely different sky atlases will be enormously popular with astronomy enthusiasts. One, *Uranometria 2000.0*, is a vastly updated edition of tightly focused and finely drawn charts. Its optional field guide provides a wealth of information on all the listed sky objects, and the entire revised and expanded new edition has been eagerly anticipated for years. The other, *The Great Atlas of the Stars*, excels at placing stellar constellations in context, combining breathtaking photography with helpful plastic overlays, well-written observing guides, and easily comprehended charts. It is more accessible to novices and provides all users with a novel, helpful, and indeed beautiful guide to the sky.

Uranometria first came out in 1987 as the most detailed atlas available to amateur astronomers. The new version, drawn by noted cartographer Wil Tirion and edited by Barry Rappaport and Will Remaklus, contains 280,000 stars—three times the number in the previous version—and over 30,000 deep-sky non-stellar objects. It is more accurate and readable than the earlier versions. Most charts must depict larger segments of the sky, so stars tend to be drawn too close together and often overlap; by contrast, the charts in *Uranometria* are drawn to a scale that enables more accurate portrayals of objects' relative sizes, brightnesses, and proximities. Finally, the field guide, by Murray Cragin and Emil Bonanno, provides, among other things, each object's coordinates, magnitude, and distance, plus notes about individual characteristics.

Where *Uranometria* focuses on the details, *The Great Atlas of the Stars* swings far in the other direction, catering to those who want to see the celestial objects as they actually appear. Brunier provides introductions to each of the constellations as well as viewing tips—what can be seen with the naked eye versus binoculars and telescopes of varyious sizes—and then points out the objects, along with constellation outlines, on the plastic sheets overlying Fujii's photography. (Fujii's marvelous work has appeared in publications around the world, and his techniques are closely guarded secrets.)

ANNIVERSARY

Charles Lindbergh and the Spirit of St. Louis

by Dominick A. Pisano and F. Robert van der Linden. Harry N. Abrams, May 2002. $22.95 (paperback)

Published in celebration of the 75th anniversary of Lindbergh's historic nonstop, solo transatlantic flight, *Charles Lindbergh and the Spirit of St. Louis* will offer readers new views of the man, the airplane, and the achievement. Authors Dominick Pisano and F. Robert van der Linden, curators at the National Air and Space Museum, chart Lindbergh's career—from his military adventures to his harrowing flights for the U.S. Postal Service—and cover the kidnapping and murder of his son and his outspoken public persona. But the focus of the book is on his ground-breaking flight. The book includes new color photographs of the airplane as well as archival images and memorabilia created to commemorate the flight.

This is a genuinely helpful feature, as identifying constellations is often trickier than one would think, especially in truly dark skies, where the greater number of stars visible tends to drown out the key constellation anchors. Flipping the overlay back and forth better trains observers for such conditions.

Both atlases have drawbacks. *Uranometria* is a heavy three-volume package that few would be inclined to drag out into the field, and the narrowness of the charts' fields—so helpful when focusing in on tight clusters—makes it very difficult to grasp exactly where you are in the sky—recognizable constellations, or even segments of them, are virtually undetectable. To make good use of this atlas, you need a baseline understanding of the sky and its constellations. *The Great Atlas of the Stars* suffers from perhaps too little information. For each constellation, only three or four objects are highlighted in the text, and the overlays, a brilliant idea, are underused. The overlays point out the dominant features and objects of each photograph, but scanning the photos reveals many more nebulas and galaxies that aren't identified. You'll have to go to another atlas to figure out what they are.

Nevertheless, these books are valuable resources. And star atlases still have an enormous advantage over computer software: Few people take their computers—even laptops—out for an evening under the stars, and charts printed from these programs have yet to achieve the smooth readability and careful selection of objects and fields of view of their professionally published counterparts.

—Eric Adams is an associate editor at Air & Space/Smithsonian.

Shuttle-Mir: The United States and Russia Share History's Highest Stage

by Clay Morgan. NASA History Series, publication SP-2001-4225. Lyndon B. Johnson Space Center, 2001. 208 pp. plus CD-ROM, $93.00 (paperback).

This official NASA history of the 1994-to-1998 shuttle-Mir program, which put a series of U.S. astronauts aboard the Russian space station to gain experience for missions to the International Space Station, has so much wonderful material that it seems only a curmudgeon or a chronic complainer would object to what was not included. And yet, from the perspective of historical accuracy, the book is indeed a failure because of the omissions.

Readers will find mission-by-mission summaries, descriptions of each of the support teams in mission control and elsewhere, beautiful photographs with detailed explanations of each scene, extensive transcripts of interviews with dozens of key participants, and much more. The contents are impressive and extremely well presented and organized. Apparently, an equally thoughtful strategy lies behind what was left out.

Author Clay Morgan, husband of astronaut Barbara Morgan, had access to the records and the participants in the project. He was assisted by a talented research team and by NASA's highly regarded history office.

Sadly, the tone of the book is that of the corporate histories paid for by companies who expect to be glorified by the writers. The author even seems to credit the shuttle-Mir program for ending the cold war, as if space cooperation were the cause of those diplomatic shifts, rather than—as many believe—the result. Astronauts and NASA public spokesmen are expected to put the best spin on their stories. But a book purporting to be history should be held to a higher standard.

Morgan makes no mention of any mistakes NASA or Russia made in the program, and characterizes all opponents as politically motivated partisans and ignorant cowards. He leaves out the dark side of many events he does mention. For example, he claims that a 1995 Mir spacewalk was canceled merely because one cosmonaut wished it to be. He does not mention that the crew actually refused orders to make the walk, a mutiny they were severely punished for when they returned to Moscow.

More serious omissions occur in discussing the national debate over the safety of the program. When the U.S. House of Representatives held hearings in September 1997, four witnesses testified, all giving prepared statements. The full text by program director Frank Culbertson is included in this book's companion CD, but a more critical view

Hunting Warbirds: The Obsessive Quest for the Lost Aircraft of World War II.

by Carl Hoffman. Ballantine Books, 2002. 256 pp., $14.00 (paperback).

Now in paperback, Hoffman's book chronicles three expeditions made by an assortment of independent salvagers to recover historic World War II aircraft from their crash sites. In one, a team attempts to revive and fly a B-29 Superfortress out of icy Greenland, where it had been stranded for 50 years. This version includes a variety of updates and clarifications.

Beyond Earth: Mapping the Universe

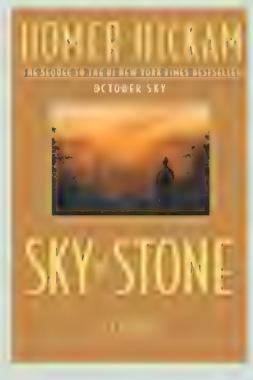
edited by David DeVorkin. National Geographic Society, 2002. 288 pp., $40.00 (hardbound).

DeVorkin, curator of the National Air and Space Museum's new permanent exhibit "Explore the Universe," assembled this collection of essays, written by prominent scientists, historians, and theorists and analyzing the gradual advancement of speculation and scientific knowledge about the universe, from ancient times up through the startling advances of the 20th century. The book is lavishly illustrated and a valuable companion to the exhibit.

Sky of Stone: A Memoir

by Homer Hickam. Delacorte, 2001. 336 pp., $24.95 (hardbound).

Retired NASA engineer Hickam, author of the acclaimed *Rocket Boys* (the basis for the movie *October Sky*), has penned a sequel that takes place in 1961, during young Hickam's first summer vacation from college, shortly after a foreman's death at the mine that Hickam's father supervises. Hickam's summer plans are sidetracked when his mother insists he return home because his father is being accused of negligence in the mines. Hickam's efforts to uncover the truth result in a richly detailed mystery.



AIRLINES

The Age of Flight: A History of America's Pioneering Airline.

by William Garvey and David Fisher. Pace Communications, Inc., 2001. 264 pp., $39.95 (hardbound).

This generously illustrated history chronicles of United Airlines' 75-year rise to airline dominance, tracking technological advancements as well as the service, marketing, and design efforts that have punctuated its growth. The reproductions of artifacts from various advertising campaigns—touting everything from destinations to cabin accommodations to attractive stewardesses—are alone worth the investment.

by NASA's own inspector general is omitted, as is the even more skeptical testimony of two of the other expert witnesses—Marcia Smith of the Libraryof Congress' Congressional Research Service and myself. There was plenty of room on the CD, and the omission is consistent with the pattern of half-truth throughout the book.

Naively, the book treats the U.S.-Soviet 1945-to-1991 cold war as some sort of turf battle between morally equivalent street gangs. The conflict, he writes, was "a situation similar to Shakespeare's 'Romeo and Juliet' with its 'two households, both alike in dignity', yet sharing 'an ancient grudge'." While he does refer to the "free" ideas in the United States, Morgan describes Soviet communism as a political system that had in contrast merely "worked for planned economies and planned lives." It is dismaying to find this misreading in an official history project funded by a U.S. government agency.

The achievements of NASA's shuttle-Mir team were very impressive, even more so when judged in the light of the program's mismanagement and the Russians' bad behavior, which are left out of this book. Genuine pride is absolutely deserved, but Morgan's over-enthusiastic claims tarnish that pride. The book is a good chronicle of the space events, an incomplete description of their context, and a poor interpreter of their historical significance.

—*James Oberg* (www.jamesoberg.com) *is a space engineer, consultant, and author; his most recent book is* Star-Crossed Orbits: Inside the US/Russian Space Alliance.

CREDITS

Hat Trick. Art "Turbo" Tomassetti has logged over 1,500 hours in the AV-8B Harrier, including combat time in Desert Storm. As a government test pilot on the Joint Strike Fighter Joint Test Force, he flew all three variants of the X-35.

You Go, Girl! Homer Hickam is the author of six books, including *Rocket Boys*, *The Coalwood Way*, and *Sky of Stone*. His most recent, *We Are Not Afraid*, was published in February.

How Things Work: Flying Upside Down. Patricia Trenner is senior editor at *Air & Space/Smithsonian*.

Russian Revolution. Debbie Gary flies an elegant Italian airplane, the SIAI Marchetti SF-260, in airshows. But since she interviewed all these other airshow pilots about their wonderful Russian airplanes, she has been dreaming about owning a multinational airplane collection.

Red Stars. Commercial illustrator and aviation enthusiast Harry Whitver also illustrated the Aichi M6A1 Seiran poster in the Oct./Nov. 2001 issue.

Restoration: Best of Seven. J. Douglas Hinton flew jet fighters in the Royal Canadian Air Force. He last wrote about the restoration of a Handley Page Halifax bomber in the June/July 2001 issue of *Air & Space*.

Armed and Anonymous. D.C. Agle is a writer and a pilot living in Southern California. He wrote "We Called It 'The Bug,' " about the Apollo lunar module (Aug./Sept. 2001).

Barfology. William Gregory was an editor at *Aviation Week & Space Technology* for 30 years.

Shooting the Moon. Bozeman, Montana-based freelance writer Joseph Bourque is currently building a Saturn V rocket in his garage in the hopes of retrieving one of Tommy Gold's cameras.

Shop Class Was Never Like This. John Fleischman's book, *Phineas Gage: A Gruesome Story About Brain Science*, has just been published by Houghton-Mifflin Children's Books, *www.hmco.com*. It's a non-fiction account of a Vermont railroad worker who in 1848 had a 13-pound iron rod shot through his brain and lived for another 11 years.

CALENDAR

April 19–21
Reunion: 22nd Military Airlift Squadron. Travis Air Force Base, Fairfield, CA, (707) 425-3895.

April 27 & 28
Arizona Days Airshow. Davis-Monthan Air Force Base, AZ, (520) 229-3204.

April 27 & May 25
Open Cockpit Day. Pueblo Weisbrod Aircraft Museum, Pueblo Memorial Airport, CO, (719) 948-9219.

May 3–5
Georgia Wings Weekend and Fly-In Pancake Breakfast. Offering free proficiency flights for general aviation pilots. Gwinnett County Airport, Briscoe Field, Lawrenceville, GA, (770) 613-9501.

May 4
Combat Fighter Pilot Seminar. Planes of Fame Museum, World War II Cal-Aero Field, Chino, CA, (909) 597-3722, *www.planesoffame.org*.

May 4 & 5
Great Valley Fly-In. More than 100 aircraft on display, paper airplane contests, pancake breakfasts, remote-controlled-aircraft demonstrations, free flights for children ages 8 to 18. Watts-Woodland Airport, CA, (530) 662-9631.

May 9–12
Reunion: 475th Fighter Group, World War II. Music City Sheraton Hotel, Nashville, TN, (931) 484-7107.

May 22–26
Popular Rotorcraft Association International Convention. More than 100 experimental and ultralight gyroplanes and helicopters, aviation seminars, kiddie rides, introductory gyro flights. Midway Airport, TX, (940) 627-9887.

May 23–25
Reunion: 4080th Strategic Reconnaissance Wing (RB-57D and U-2 aircraft). Civic Center, Del Rio, TX, (830) 775-5346.

May 31 & June 1
Biplane Expo Fly-In. Bartlesville, OK, (918) 622-8400.

June 1 & 2
Experimental Aircraft Association Family Flight and Balloon Festival. Hot air balloon competition, helicopter flights, kite-making classes, and more than 100 aircraft on display. EAA Aviation Center, Oshkosh, WI, (920) 426-4800.

Organizations wishing to have events published in Calendar should fax press releases two months in advance to (202) 275-1886 or mail them to Calendar, Air & Space/Smithsonian, *MRC 951, PO Box 37012, Washington, DC, 20013-7012.*

In the Wings...

The Aerodynamicist
With a sixth sense about air and the wind tunnels at NASA's Langley Research Center, Richard Whitcomb changed the shape of wings and airplanes.

Guys Who Like To Blow Things Up
Any aircraft headed for combat first has to survive the sharpshooters at the Navy's weapons survivability laboratory.

The Mystery of Flight 427
From a 1994 USAir crash came one of the broadest airworthiness directives ever issued by the Federal Aviation Administration.

Helicopter Capital of the World
Calling "Taxi!" in Sao Paulo, Brazil, may really get you a lift.

TIM WRIGHT

Richard Whitcomb, 81, is best known for an insight in 1951 that led to the Transonic Area Rule.

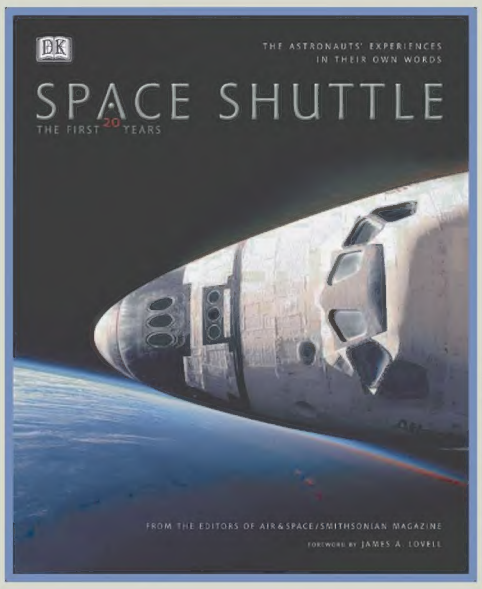
The Birth of Spooky
During the Vietnam War, who put the "A" into AC-47?

Collateral Damage
How the attacks of September 11 reverberated all the way out into the world of small airports and general aviation.

Lone Star Observatory
What prosperous Texans do at night.

ON THE WEB SITE

www.airspacemag.com



AIR & SPACE/SMITHSONIAN

View rarely seen photographs documenting the voyages of the U.S. space shuttle. The photos, many published for the first time in the newly released book *Space Shuttle: The First Twenty Years*, may be ordered as posters.

The book is an unprecedented collection of personal recollections from 77 space shuttle astronauts, the largest number ever presented in a single volume. Through exclusive interviews with the editors of *Air & Space*, the astronauts tell in candid detail what it's really like to launch into orbit, float weightless, conduct spacewalks, view the Earth from 200 miles up, build a space station, and rustle seven-ton satellites by hand.

The book also includes summaries of all 100-plus shuttle missions flown since 1981, a reference section explaining how the Space Transportation System works, and more than 300 photographs in 320 pages. To order *Space Shuttle: The First 20 Years* from the publisher, Dorling Kindersley, call (800) 847-5515.

See the moon in 3-D! Photographs taken by the Apollo astronauts of the lunar surface (as seen in the article "Shooting the Moon," p. 54) may be viewed with 3-D glasses. Directions for ordering glasses FREE are also posted on the Web site.

Watch the X-35B, one of Lockheed Martin's concept demonstrators for the Joint Strike Fighter, on the short takeoff, hover, and vertical landing it made prior to the record-setting Mission X flight (Above & Beyond, p. 16).

COURTESY TOMMY GOLD/CORNELL UNIVERSITY

The Greatest Great Circle

Flying around the world is not an undertaking that most pilots are likely to attempt, but the Fédération Aéronautique Internationale is hoping a new Circumnavigator Badge will stimulate greater interest in the feat. The people who have accomplished an around-the-world flight in recent years (more than once in some cases) have their own Web site—*www.earthrounders.com*—where they report their activities and post notices of records and events. Last February the site tracked Flemming and Angela Pedersen and Trevor Sherwood as they made their way eastward around the globe in a 1965 Mooney M20E.

The first circumnavigation of the globe was made by the U.S. Army Air Service. Four Douglas World Cruisers departed Seattle, Washington, in April 1924. Only two aircraft survived the 27,553-mile trip, completed almost six months later. The most well-known circumnavigation is that of Dick Rutan and Jeana Yeager, who in 1986 took off from California's Edwards Air Force Base in the homebuilt *Voyager* and returned nine days later, having flown around the world nonstop and unrefueled.

The FAI Circumnavigator Badge can be earned by any pilot with at least a private certificate who circles Earth along an eastbound, westbound, or polar route, as defined by FAI rules. The flight may be nonstop or broken into segments, and may be flown solo or with crew members. Some restrictions:

- The same aircraft must be used for the entire flight. Engines and other components can be replaced if necessary, but the basic airframe (wings and fuselage) cannot be altered.
- All applicants must be aboard the aircraft for the entire flight (though not necessarily at the controls).
- The aircraft must be flown under its own power for the entire flight.
- The pilot must return to within 400 kilometers (approximately 250 miles) of his or her starting point.
- The flight must be completed within 365 days.
- Pilots must hold an FAI Sporting License.

Pilots flying east or west must travel at least 27,000 kilometers (16,777 miles) and cross all meridians. Pilots flying a polar route must travel at least 34,000 kilometers (21,127 miles) and cross the equator at two points separated by at least 90 degrees.

—Stuart Nixon

The first circumnavigators were the Douglas World Cruisers. The most noted was the Voyager *(top).*

TOP: CHRISTOPHER SPRINGMANN; BOTTOM: NASM NEG#A2709C

Moments & Milestones is produced in association with the National Aeronautic Association. Visit the NAA Web site at www.naa-usa.org *or call (703) 527-0226.*

LOGBOOK

Events

The 2001 Robert J. Collier Trophy will be presented at a dinner held by the National Aviation Club on May 29, 2002, at the Crystal Gateway Marriott in Arlington, Virginia.

Nominations

The NAA is accepting nominations for the 2001 Harmon Aeronaut (Ballooning) Trophy—the most outstanding achievement in the art and/or science of ballooning—through May 31.

For further information, call (800) 644-9777 or e-mail awards@naa-usa.org.

Records

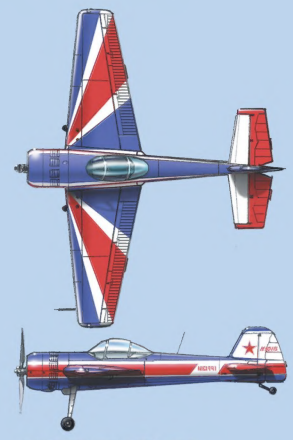
Memorable Aviation Records of 2001:

- AeroVironment's unmanned solar wing, Helios, set an altitude record of 96,863 feet over Hawaii last August.
- Davis Straub broke his record of 348 miles with a 10-hour hang glider flight covering 407 miles over Texas last July.
- Parker Johnstone and James Murphy flew a Beechcraft Bonanza 36 to all 96 hard-surface public airports in Oregon last June within 31 hours and 16 minutes. Beside setting a record, the flight raised $10,000 for the Make-a-Wish Foundation and the American Diabetes Association.
- Northrop Grumman's unmanned Global Hawk set a distance record when it flew 8,214 miles from California to Australia in a little less than 24 hours nonstop.
- Stephen Fossett set a record for time aloft in a balloon, though he failed to fly solo around the world. Bad weather over the Atlantic forced him to set down in Brazil after 300 hours and 57 minutes aloft, 12 days spent drifting across the Pacific from Australia.
- Richard Keyt set a speed-over-a-500-kilometer-course record last July by flying his Polen Special II from Oshkosh, Wisconsin, to Monticello, Iowa, and back in 70 minutes, for an average speed of 303 mph.

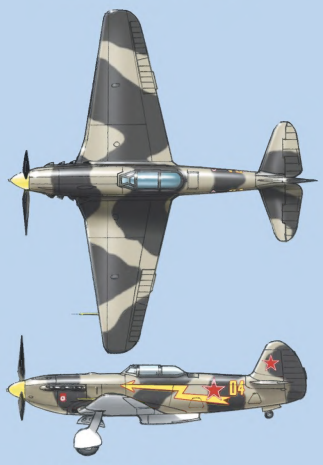
RED STARS

RUSSIAN AIRCRAFT NOW PLAYING AT U.S. AIRSHOWS

SUKHOI SU-26
The Su-26 debuted at the World Aerobatic Championships in 1984 but triumphed in 1986 as the Su-26M. A welterweight at 1,500 pounds, the -26 is more than 50 percent composites and has squared-off wings, nearly full-span ailerons, and a roll rate of 345 degrees per second.



YAKOVLEV YAK-55
Another Russian aerobatic champ, the all-metal Yak-55 is heavier than its Sukhoi rival—and cheaper. (A British dealer who sells both aircraft says the -55 "will give 85 percent of a Sukhoi's performance at 40 percent of the cost.") The Yak uses the same 360-hp Vedeneyev M-14P radial engine as the Su-26.



YAKOVLEV YAK-9
The aircraft that helped turn back the Germans at Stalingrad in World War II, the Yak-9 was produced in greater numbers than any other Soviet fighter—20 a day in mid-1944. To see a vintage Yak-9, visit the Champlin Fighter Air Museum in Mesa, Arizona, which displays the only original in the United States. Today's flying models are newly manufactured Yak-9U-Ms, fitted with 1,500-hp Allison V-1710 engines and second seats.

AERO VODOCHODY L-39
Since 1974 more than 25 air forces around the world have trained for jet combat in the Czech-built, two-seat L-39 Albatros. Russia has been the chief customer, buying 2,080 of the short-wing, 485-mph aircraft.

MIKOYAN GUREVICH MiG-15
Despite the 35-degree sweep of its wings, the MiG-15 remained stubbornly subsonic even in dives. But the jet weighed 3,000 pounds less than most of the North American F-86 Sabre variants it faced in the Korean War and could climb to 30,000 feet twice as fast.

RUSSOPHILIA Since the early 1980s, when Yaks and MiGs began appearing in U.S. airspace, the American airshow crowd has become increasingly fascinated by the exotic Easterners and their aerobatic or trainer comrades. Today Sukhoi's latest designs, newly manufactured Yaks, and other aircraft from the former Eastern Bloc, have joined vintage Russian warbirds on the circuit. All will fly this season in shows from San Diego to Atlanta.

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GRAB LIFE BY THE HORNS

DODGE

IF ALIENS ARE SO ADVANCED, WHY HAVEN'T THEY DEVELOPED ONE OF THESE?